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COST OF PUMPING WATER AT ISLETON.
BY A. F. BRIDGE AND RALPH REYNOLDS.

RECLAIMED LANDS.
BY R. B. MATEER.


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# COSTS OF PUMPING WATER AT ISLETON

BY A. F. BRIDGE AND RALPH REYNOLDS.

An interesting result of modern long distance transmission of electrical energy is found in the Sacramento Valley delta district.

Water is diverted from its habitual course in the Feather River and passed through Francis turbines. The power thus obtained is transferred some hundred miles down stream where it is utilized to pump this self same water back into the original channel. This seemingly wasteful use of water is due to the tremendous agricultural value of river bottom land.

The lower end of the great Sacramento-San Joaquin River system is a net-work of sloughs, canals and streams, which spread over a great triangle between the two rivers, with its apex at the lower end of their confluence. The innumerable islands formed by these intermingling channels are very low, due to their alluvial character.

The value of the soil in the upper portion of this district, from the farmers' standpoint, was early realized and even in the pioneer days of California, great crops of wheat were loaded upon sternwheelers and shipped down to San Francisco, thence to consumers all over the world. When the land would no longer produce wheat, the farmers turned to other things; such as fruit or alfalfa. This movement gradually led to the reclaiming and developing of the islands lower down and which had hitherto been considered uninhabitable, because of the danger of floods. There is, hence, in this region a large acreage of what is claimed to be the richest land in the world, devoted to the cultivation of alfalfa, fruit, asparagus, hops and potatoes, a checkerboard of farms interlaced with navigable channels, which bring cheap transportation facilities right alongside.

Sacramento River Scene Near Isleton.

To snatch these prizes from under the Sacramento, it was necessary to build high levees and install large pumping plants to remove surplus water during spring freshets when the Sierra snows are melting rapidly.

These protective embankments have given the country its name—"The Netherlands." There are Dutchmen there, too, as well as Chinese, Japs, Hindus, Portugese, and occasionally a Native Son.

These "reclamation plants" as they are called, are somewhat of an improvement over the old dutch windmills which have proven too unreliable for the modern farmer. Floods are liable to come in a few hours.

Low pressure (reciprocating) or plunger pumps, direct-connected to steam engines were the typical early installations. Such plants represented a large investment and required skilled attendance, but they were all that were available until quite recently.

Island District of the Sacramento and San Joaquin Rivers.

The farmers soon began to "go nature one better"—to force their crops by irrigation. The islands are mostly above the river level during its low stage, which coincides with the irrigation season. Hence, it is necessary to raise the water. The customary outfit for this work was a single cylinder gas engine of from 2 to 20 h.p., driving a low head centrifugal pump. These irrigating plants are a more recent development, and while they operate for a longer period, the capacity is usually far less than that of the reclamation pumps. These latter vary from 75 to 500 h.p. and are designed with a large safety factor with regard to size, since in case of floods it is extremely desirable to have a pump capable of handling the water in any emergency.

Both types of equipment were satisfactory in operation and each well adapted to its particular purpose. Competition has, however, entered the field in shape of cheap and reliable electric power. This is due to the advent—within the last few years of the Great Western Power Company's transmission system—a new and enterprising concern which has lately constructed a maze of lines in this region as complex as the river itself.

The main line, a double circuit 100,000 volt system, passes through the region in a general north and south direction. The Great Western Power Company, realizing the market for power in this vicinity, erected a substation near Isleton at the southern extremity of a 1600 ft. span across the river. Here three single-phase General Electric, water-cooled shell type, 23,100 volt transformers are connected in delta to the high tension line.

### The Substation.

The station is a steel frame structure covered with galvanized corrugated steel sheets. The primary leads enter the station through porcelain bushings supported in the roof. They run to a Thomson, manually operated, remote control, oil switch, located immediately behind the transformers, which are interconnected on the high side by short leads or jumpers. The transformers are located in the center of the building and carried on rails embedded in the concrete floor. This permits of any of them being slid forward, and under a chain hoist where the coils and core may be readily removed for inspection or repairs. The cooling water is forced by gravity through the coils from a steel tank outside the station and discharges into the river. Telltale check valves are so placed in the pipes as to be easily visible to the operator and serve to indicate any cessation of the supply. The secondaries connect directly to a 2300 volt transformer bus without any intervening switches. The feeder bus is separated from the transformer bus by a K-21 General Electric oil switch. The transformers are protected against high frequency surges by aluminum cell lightning arresters. Taps are taken off the transformer bus through choke coils to the arresters, which are set in a concrete base just outside the station. These are fitted with arc rupturing horn gaps in accordance with latest practice.

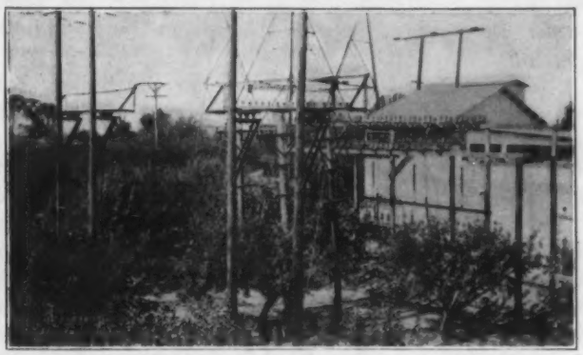
From the feeder bus, lines connect with Brighton, Venice Island and the northwestern division through Rio Vista and Napa. These circuits are all controlled by K 12 General Electric oil switches. Just south of the building an auxiliary bus mounted on poles and arranged to connect the transformer bus and all the 23,000 volt feeders through pole top, air-break switches, thus affording a simple means of completely isolating the feeder bus to facilitate alterations and repairs.

Power is taken from the feeder bus through K-12 oil-breakers for 3 delta connected, 50 k.v.a., 23,000/2300 volt oil-cooled transformers. These are inside the station and furnish 2300 volt service over a 3 mile line to Isleton and the vicinity of Walnut Grove.

The feeder switches, sectionalizing switches and instrument transformers, are mounted along the south wall on a steel frame structure. This also supports the bus and suspension insulators from which the various circuits are led through outlet orifices in the south wall. An instrument panel is placed immedi-

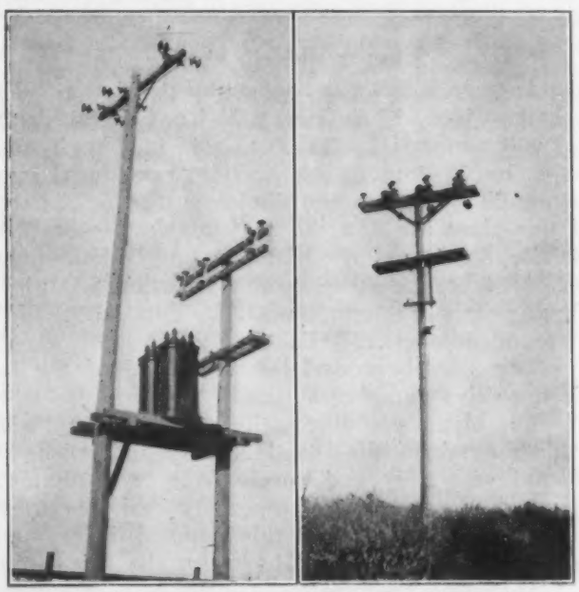
ately below each switch as is also the automatic overload tripping device.

Totalizing and 2300 volt feeder panels are located opposite the center of the bus structure, the instru-



View of Isleton Substation Showing Auxiliary Bus and Pole Top Switches, Dead Ending of High Line Taps With Crossing Tower in Back Ground.

ment taps being led through conduits below the floor. Each feeder panel is equipped with polyphase indicating and integrating wattmeters and the station



Pole Switches With 2300 and 23,000 Line Construction.

total output panel contains ammeters for each phase, a curve drawing wattmeter recording and indicating volt meters.

### Distributing System.

The lines mentioned above are at present constructed and in operation and the system is being rapidly extended so as to form a comprehensive network throughout the entire valley. The development is according to a well formulated plan. The 23,000 volt lines form the trunk or distributing mains and radiate from the Isleton station to points determined by the local consumption.

Here outdoor 23,000/2300 substations are located which tap off from the mains and feed the secondary 2300 volt busses. These substations are uniform in their construction and consist of 2 oil-cooled transformers with capacity from 75 to 150 kw. They are mounted on a wooden framework between two poles and elevated some 10 ft. from the ground. Primaries and secondaries are V connected, the former through pole switches. No protection from the elements is attempted and so far no interruptions of service have occurred due to injury from rain, etc. These installations are in reality large pole transformers and resemble them in every respect. The 2300 volt lines are usually about 2 to 6 miles long and supply power for pumps through 2300, 220-440 volt open delta pole transformers located at the point of consumption. With few exceptions the energy undergoes four transformations of pressure before being utilized—11,000/90,000/23,000/2300/220.

### Submarine Cables.

The circuits are all carried on pin type insulators supported by double cedar cross-arms and poles of 50 ft. average height. All three conductors are mounted on the same cross-arm and are not transposed. In many instances and wherever possible the same pole line serves for both 23,000 and 2300 lines, the former being carried on the upper cross-arm. Where it is necessary for the trunk line to cross a slough of considerable width or one open to navigation a three core sheathed submarine cable is laid. These have given excellent service but are occasionally damaged by logs, anchors, etc. The Venice line feeds the southern part of the district. The Brighton feeder supplies the region north of the river and extends to the Brighton substation via Glide, thus linking this station and Isleton substation together. In emergency, Brighton may feed back and supply the northwestern division through Isleton but at the expense of good regulation, since under these conditions the line drop is excessive. The Rio Vista line carries power into the northwestern division extending as far as Santa Rosa.

Owing to the rigid requirements of the reclamation service the power company is now engaged in rapidly tying together both their 23,000 and 2300 volt lines so that any point may be fed over two or more independent routes. Thus the insurance of continuous service to any one consumer is multiplied. The additional reliability fully warrants the increased expenditure.

### Load.

The connected load of the Isleton station on the basis of installed capacity consists of about 150 kw. in lighting and 2426 h.p. in pumping plants of various kinds. This latter comprises the greatest part of the load and consists of two classes, reclamation 12,425 kw. and irrigation 627. The former represents only 11 installations, however, and the latter 68, with average capacities of 113.0 and 9.25 kw. respectively.

### Reclamation.

Practically all the reclamation plants are owned by organized districts incorporated by private enterprise. They are formed for the purpose of draining the land owned by the stockholders. This load is strictly of a 24-hour nature during the flood season and hence can not be dropped over the daily peak.

Some of the reclamation pumping plants have been in operation for 20 years. The process of reclaiming the land consisted of building a levee around an island and then pumping out the water, hence

every new island that was opened up had its own equipment. Five years ago all of these were driven by steam engines burning oil fuel. The first cost of the plant of this character was high. This was inherent in the steam plant on account of the cost of auxiliaries—feed pumps, boilers, oil pumps, condensers, etc. The cost of maintenance and attendance was also a considerable item since a competent steam engineer was required to properly operate the plant.

### Ryde Plant.

A brief history and description of one of these will illustrate the general type of installation. The Ryde plant was installed 19 years ago at Ryde on the south side of Grand island when the island was first being drained. As originally placed in commission, the plant consisted of a 44 in. B. J. single-stage centrifugal pump, direct connected to a B. J. 2-cylinder cross compound steam engine. The pump operated at 160 r.p.m. and discharged 42,000 g.p.m. into the river through a 44 in. pipe line under the levee.

Pump Placed Outside of Levee at the Ryde Plant.

The indicated h.p. of the engine when the pump is discharging against a net head of 13 ft. is 210. The normal pumping period is approximately six months, beginning in December. However, this is subject to tremendous fluctuation depending on the precipitation of snow and rain. For instance in the season 1911-12 no pumping was necessary at all, in 1910-11 the plant was in operation practically throughout the entire year. The average total annual operating cost taken over a period of five years, with this equipment was $1400.

This year a duplication of motive power has been made in the shape of a 350 h.p. type I, 440 volt, 360 r.p.m. General Electric induction motor. This is arranged to drive the pump through a 36 in. rubber belt and a 90 in. pulley on an extension of the engine shaft, as shown in the illustrations. This motor drives the pump at 170 r.p.m. at which speed the normal delivery is 45,000 g.p.m.

Multigap General Electric arresters are employed as protection against high frequency surges. A 12 in. x 16 in. triplex Gould vacuum pump is used to prime the suction line. It is belt driven by a General Electric 5 h.p., 440 volt induction motor.

The power is obtained from the 23,000 volt distributing line and stepped down in 3-100 k.v.a. oil-cooled transformers located in a small galvanized shed separate from the pump house.

During the summer months it is necessary to irrigate this island and this is accomplished in a unique manner. The connecting rods of the steam engine are removed and the flange coupling, through which the motor drives, disconnected. The discharge line is then primed through a bypass to the vacuum pump and water is siphoned in from the river, the pump runner revolving freely in the reversed direction as a turbine.

It is intended to keep steam on the boilers continuously during the wet season to prevent cessation of pumping in case of any failure of the power supply. As regards comparative operating costs no data is at present available since the motor has not been in active operation as yet. However, the rate schedule of the power company is based on the monthly load factors with a minimum of $6 per h.p. per year of maximum demand. Thus the minimum charge possible with the pumping is about $1400. It may readily be seen that no saving in this item has been made, and in addition there are the maintenance and attendance charges on motor besides the cost of keeping steam on boilers. However, the presence of the motor and steam drive is effective insurance against loss of property by flood and as such the owners are more than willing to pay the additional cost provided the service is dependable.

### Smith-Riddell Plant.

Another installation, owned by the Smith-Riddell Company, is at Lisbon. Here a 75 h.p. General Electric 220 volt motor is connected to a 15 in. Krogh single stage, heavy duty double suction, centrifugal pump having 20 in. suction and discharge pipes. The costs of this plant are itemized as follows: Motor, $642; starting compensator, $7.62; casing, $450; pump, $613.43; labor for erection and foundation, $200; labor digging ditch through levee, $75. Total, $1987.05, or in round numbers, $2000.

This may be considered as typical of the new electric drive pumping outfits.

The plants are universally of this general character throughout the island country and when considered separately and purely from a load factor standpoint they are not especially desirable to the power company. When this demand is combined with the irrigation load, however, the annual load curve is smoothed out considerably. This fitting together is the result of the wet and dry seasons. The draining period runs from December to April, while the irrigation season for most crops, lasts from June to October. Oftentimes they overlap.

### Irrigation.

Irrigation is usually carried on by small plants operated independently by the farmers, except in the interior of some of the large islands and on the high lands in the vicinity of Galt and Lodi, where the water is taken from the river. The maximum lift is 20 ft. and ranges down to 6 ft., depending on river height.

In former years it was common practice to lay the suction pipe through the levee. The advocates of this method claimed lower first cost of pipe; no siphon to prime in case air leaked in; reduced friction head; and fewer joints and elbows. However, it was found in practice that if the pipe through the levee developed a leak in time of high water, such an arrange-

ment might cause a disastrous break in the dyke. Another disadvantage arose that unless this insertion was protected by a concrete bulkhead, on each side, the rats and gophers burrow through alongside the pipe and weakened the levee. Repairs to the pipe line are expensive since a large amount of excavation must be done. For the public safety laws are now in effect which do not allow placing the pipe more than 3 ft. under the levee.

In some places, the pump is located outside the levee with the suction pipe vertical and discharging over the levee. More frequently the pump and motor are housed on the inside and the water siphoned over. The first has the advantage of less priming, a minimum of leaks in suction pipe, and fewer joints, but it is liable to submersion during high water, and since safety of the outfit is the determining factor, the pump should be protected by the levee. There are some thirty irrigation pumps now in operation in the islands of which more than 75 per cent are motor driven. Of these, all are belt driven with one exception. The advantage of this form of drive over direct connection is that, by changing pulleys, the pump speed may be altered to suit the variation in head. A high speed motor, about 1700-1800 r.p.m., may also be used. Thus a cheaper motor and a stock pump may be successfully employed, whereas with direct connected outfits a special pump design and expensive slow speed motor are required, even where the head is constant. From 5 to 15 per cent of the transmitted power is consumed in belt slippage.

### Andrus Island Plant.

The outfit of the Andrus Island Company, which is shown in accompanying illustrations is a good representative of the type of plant used. It is located on the south bank of the river near Isleton, and is contained in a galvanized shed inside of the levee. This is a 10 h.p. Westinghouse, 220 volt motor, driving a 6 in. Eclipse pump through a belt. The net head is low, about 8 ft. The suction pipe runs up over the levee as shown and an ordinary hand lift pump is used to prime the suction line. The pump and motor are mounted on a concrete foundation and the

Suction and Discharge Lines with Sump, Andrus Island

Hand Lift Priming Pump on Top of Levee Andrus Island

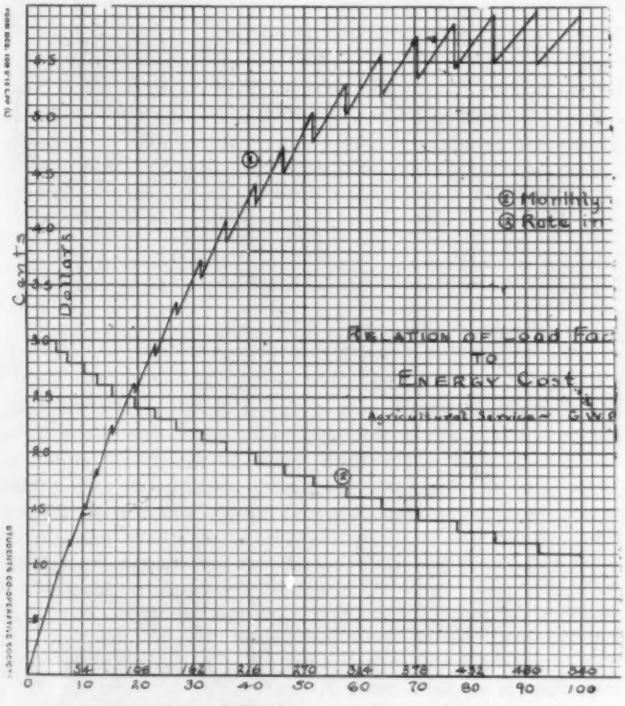
starting compensator switches and fuses are carried on a wooden wall panel. The discharge pipe terminates in a concrete pump from which the water is distributed by gravity ditches. The suction line is of 17 in. flanged casing about 90 ft. long and discharges some 9000 gallons per minute.

The over-all efficiency of the plant is itemized as follows:

| | |
|---|---|
| Pump | 63 per cent. |
| Motor | 87 per cent. |
| Resultant | 54.7 |

This is exclusive of loss in transformers and connections as it should be since the energy consumed is metered at the motor and such losses are not chargeable to the consumer. The cost of energy is determined according to the following schedule based on the load factor and is uniform for this character of service.

| Monthly Consumption. | Monthly Charge per h.p. installed. | Load Factor. | Rate per kw.-hr. |
|---|---|---|---|
| Less than 31 kw.-hr. per h.p. | $0.00 0.93 | 0- 5.6% | 3c |
| From 31 to 42 kw.-hr. per month. | 0.90 1.22 | 5.6- 7.6 | 2.9c |
| " 42- 55 " " " | 1.18 1.54 | 7.6- 10.2 | 2.8c |
| " 55- 70 " " " | 1.49 1.89 | 10.2- 12.9 | 2.7c |
| " 70- 86 " " " | 1.82 2.24 | 12.9- 15.9 | 2.6c |
| " 86-105 " " " | 2.14 2.62 | 15.9- 19.5 | 2.5c |
| " 105-124 " " " | 2.52 2.98 | 19.5- 23.0 | 2.4c |
| " 124-146 " " " | 2.86 3.36 | 23.0- 27.0 | 2.3c |
| " 146-169 " " " | 3.22 3.72 | 27.0- 31.3 | 2.2c |
| " 169-194 " " " | 3.55 4.08 | 31.3- 36.0 | 2.1c |
| " 194-221 " " " | 3.88 4.42 | 36.0- 41.2 | 2.0c |
| " 221-250 " " " | 4.22 4.75 | 41.2- 46.3 | 1.9c |
| " 250-280 " " " | 4.50 5.04 | 46.3- 51.8 | 1.8c |
| " 280-312 " " " | 4.76 5.30 | 51.8- 57.8 | 1.7c |
| " 312-346 " " " | 5.00 5.54 | 57.8- 64.0 | 1.6c |
| " 346-381 " " " | 5.19 5.72 | 64.0- 70.5 | 1.5c |
| " 381-418 " " " | 5.33 5.85 | 70.5- 77.5 | 1.4c |
| " 418-457 " " " | 5.44 5.93 | 77.5- 84.5 | 1.3c |
| " 457-498 " " " | 5.48 5.96 | 84.5- 92.2 | 1.2c |
| " 498-540 " " " | 5.48 5.94 | 92.2-100.0 | 1.1c |
| " 540 " " " | $5.40 | 100.00 | 1.0c |




Relation of Load Factor to Rate per kw.-hr., and Total Monthly Charge per h.p. of Maximum Demand.

A minimum fixed charge of $6 per h.p. yr. is made.

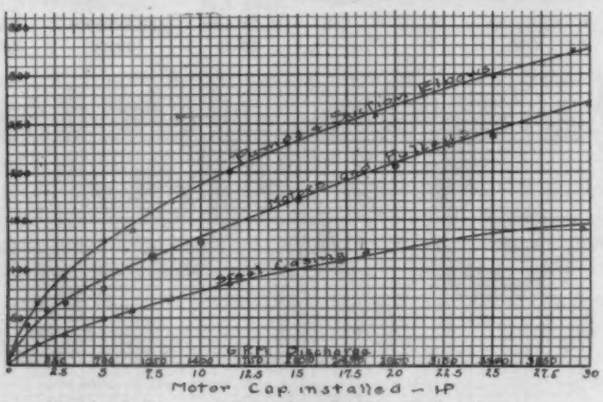
The load factor for such consumers is defined as the ratio of average load (taken over a period of 1 month) to the maximum possible demand of the in-

stalled apparatus. This necessitates testing of the plant to determine this consumption, which tests are made by the power company. Results show some variation due to the seasonal change in head. On account of the nature of the demand the fact that no winter irrigation is employed and the longest pumping season is 6 months, it is obvious that the yearly load factor can not exceed 50 per cent unless the motor is used for other purposes during the idle period. The load factor averages around 20 per cent.

### Summary of Typical Plant.

1. Horizontal centrifugal pump, belt connected.
2. Three-phase, 220 volt, squirrel cage, induction motor, and starting compensator provided with no voltage release.
3. Rubber driving belt.
4. Foot or check valve.
5. Suction line, hand-operated, priming pump.
6. Overload release, fuses on both.
7. Motor switch (air break).
8. Piping (usually 1 in. larger than pump).
9. Shed, concrete foundations, pump, etc. The transformers and meter are supplied by the power company.

The first cost of a typical plant, a 6 in. pump, 10 h.p. motor, and all necessary equipment as itemized above together with 125 ft. of 8 in. flange, joint steel casing, installed complete with concrete foundations, is $575. The cost curves shown elsewhere represent the averages of some 60 plants in this region. The




Itemized Costs of Pumping Outfits Under Average Head Conditions.

**Explanation of Curves.**

The above chart is best explained by a concrete example. Suppose a farmer requires 1450 g.p.m., according to the curve the pump would cost $190, and the motor of 10.4 h.p., $133. But an eight-inch pump with normal delivery of 1600 g.p.m., is necessary and this will require a motor of 10.9 h.p. The nearest size is 15 h.p., hence the eight-inch pump costs $200 and the motor $169, a total of $369 actual, as against $323 from the curve. The cost of the house or shed which incloses the pump, varies over such a wide range, depending on whether it is of wood, galvanized iron or concrete, and the nature of the foundation that it is not practicable to incorporate it in the form of a curve.

average head is taken at 15 ft. with a motor efficiency at rated output of 88 per cent. They indicate the first cost installed and are fairly accurate. The initial investment is all that is available at present, since most of the pumps have been in operation for so short a time that no data has been obtained in operation and maintenance costs. From a few isolated figures, the conclusion is that for the load factors which usually prevail, the cost of operation alone is greater by about 10 per cent with motor than with an internal combustion engine burning distillate. This fuel is obtainable in this region at a rate of 10c per gallon, including freight. However, this is when the gas engine is new and at its maximum efficiency. With wear, loss of compression and leakage soon result. A motor does not deteriorate nearly as rapidly, neither should the two types of drive be compared on the basis of equal rating since the gas engine has no overload capacity, even instantaneously. The latter for a given possible output costs from 2 to 3 times as much as the equivalent motor, hence the interest on investment is often the determining factor in favor of the motor. The increased convenience, reliability and low attendance and maintenance charges are the best arguments in favor of electric drive and appeal strongly to the farmers.

Past and Present in the Pumping Art.

In conclusion, as most of the land available is at present under cultivation, growth and increased output is only obtainable by intensive farming which may be the best accomplished by careful irrigation. Water is plentiful and the probable growth of the demand for electric power in this region seems limitless.

## CONCESSIONS AT THE PANAMA-PACIFIC EXPOSITION.

According to Director of Concessions Frank Burt, more than twenty-four concessions have already been granted by the 1915 Exposition. Of this number some of the leading attractions will expend $1,505,000 in preparing for the entertainment of thousands of visitors who are coming to the Panama-Pacific International Exposition. Following is a partial list:

| Name. | Concession. | Amount to be Invested. |
|---|---|---|
| Remington Typewriter Co. | Public Stenographic Booths | $ 150,000 |
| Santa Fe Railroad | Grand Canyon of Arizona | 250,000 |
| Drs. Couney & Fischel | Infant incubators | 25,000 |
| L. E. Myers | Panama Canal | 150,000 |
| L. E. Myers | Panamanian Souvenirs | 25,000 |
| Dale, Davis & Lewis | '49 Camp | 100,000 |
| Orange Blossom | California Candies | 10,000 |
| Patrick Brothers | Ice Palace and Hockey Arena | 150,000 |
| Pacific Aeroscope Company | Aeroscope | 100,000 |
| Marcel Clessinger | Trianon | 60,000 |
| E. W. McConnell | Creation | 160,000 |
| E. W. McConnell | Evolution of the Dreadnaught | 150,000 |
| E. W. McConnell | Cyclorama Battle of Gettysburg | 25,000 |
| E. W. McConnell | Human Roulette | 15,000 |
| L. A. Thompson | Scenic Railway | 60,000 |
| L. A. Thompson | Racing Coaster | 60,000 |
| C. L. Seipt | The Old Mill | 15,000 |
| Total | | $1,505,000 |

# ELECTRICAL PUMPING AND IRRIGATION

## DIVERSION WEIRS ON PERVIOUS FOUNDATIONS.

BY B. A. ETCHEVERRY.

The construction of diversion weirs on pervious foundations has usually been based on the design of existing structures of the same type and under the same conditions, modified according to the judgment and experience of the engineer. The principles which should control the design of such weirs have been more or less empirical. In a recent book on the Practical Design of Irrigation Works, the author, W. G. Bligh, a retired executive engineer of the Indian Public Works Department, has evolved principles of design for such works based largely on the dimensions of successful structures in India. These principles, as well as experiments on the passage of water through sand by Lieutenant-Colonel J. Clibborn of Roorkee, India, while derived from practice in India, are no doubt applicable to similar conditions in other regions.

**Types of weirs.**

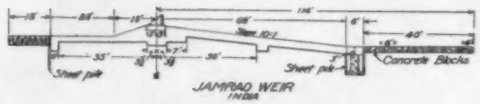
The diversion weirs on sand, used in India, are of three types: (1) those which consist of a direct fall on an apron; (2) those which consist of a low wall with an upstream floor extending from the stream bed and sloping up to the crest of the wall, and a downstream masonry inclined impervious floor sloping down from the crest of the wall to the stream bed and continued with riprap or paving. The crest of the wall is often equipped with collapsible shutters; (3) those which have a flat triangular profile similar to the second class but built of loose rocks and a number of parallel cross walls, one of which is placed on the crest line and forms the crest. The upstream floor slopes up from the stream bed to the crest on a slope usually 1 on 3 or 1 on 4, and a downstream or rollerway floor sloping from the crest to the stream bed on a slope ranging from 1 on 10 to 1 on 15, de-

pending on the character of the stream bed. The Laguna weir is of this type, differing from the weirs in India, in that the walls are extended down below the stream bed. Sheet piling is used below the crest wall. In India the walls extend only down to the stream bed. This class of weir differs from the first or second class in that the apron is not impervious and therefore not subject to hydrostatic lift.

The first type of weir, modified often by shaping the downstream face of the weir, is the type most commonly used in the United States, and for this reason will be considered separately, although the general principles of design are applicable at least in part to the other types. The first type of weir consists of the superstructure or weir wall, the downstream impervious floor or apron with an extension of riprap or paving, a cut off wall or sheet piling at the upstream toe of the weir wall and at the lower end of the floor, and in some cases an upstream floor.

**Forces acting on weir.**

The forces acting on a diversion weir on pervious foundations include in addition to those acting on a weir built on an impervious foundation, the hydrostatic uplift and the underflow transportive or erosive force. The superstructure or weir wall which is supported on the impervious floor and built with it, is designed to resist the maximum resultant pressure in the same manner as if founded on an impervious bed. The design of the other parts of the weir are determined by the hydrostatic uplift and the underflow erosive force. The hydrostatic uplift is due to the difference in elevation between the water levels




on the upstream side and downstream side of the weir. The underflow erosive force depends on the velocity of the undercurrent which for any material will be directly proportional to the difference in elevation of the water levels and inversely proportional to the length of the path of percolation. The important principles of design of weirs on sand foundation are: (1) the floor must be designed of sufficient thickness to resist the uplift; (2) the path of percolation under the weir must be made large enough to offer sufficient resistance to the underflow to prevent the undermining of the structure.

**Hydrostatic uplift pressure.**

A consideration of the principles of underflow is necessary to understand the principle of design. As stated above, the hydrostatic uplift is due to the difference in elevation between the water surfaces on both sides of the weir. The maximum uplift will occur when the difference in elevation is greatest, which is when the flow is minimum. For streams of low minimum flow or where the low flow is entirely diverted through the headgates, the maximum uplift will be obtained when the water level on the upstream side is level with the crest and when the stream below is dry or when the depth of tail water a minimum. The intensity of pressure is a maximum at the upper end of the path of percolation and is equal to the head producing the underflow. From this point the intensity of pressure diminishes in proportion to the length the water has to creep and is zero at the lower end of the path of percolation. The principle is similar to that of a horizontal pipe filled with sand and equal in length to the length of the path of percolation, connected at one end to a reservoir at a depth below the water surface equal to the head represented by the difference in elevation between the water surfaces on both sides of the dam, and with the other end discharging freely into air.

The intensity of pressure at any point along this line is represented by the head measured from this point to the hydraulic grade line.

**Path of percolation.**

From experiments made in India it has been found that in considering the uplift pressure the path of percolation is not the shortest line between the inlet and outlet, but the path formed by the surface of contact between the material of the stream bed and the different parts of the foundation of the weir, so that if water-tight cut-off walls or sheet piling be used, both at the upper toe of the weir and at the lower end of the floor, and placed not closer to each other than twice their depth, the path of percolation will be down the upstream face of the wall and up along its downstream face, then along

the floor in between and down and up the second cut off wall. The effect, therefore, of using cut off walls is to increase the length of the path of percolation by twice the depth of earth wall. While the effect of the cut off wall at the upper toe of the weir is to decrease the uplift on the floor, the effect of the lower cut off wall is to increase the uplift. The same effect obtained with the upper cut off wall can be produced by constructing an impervious floor on the upstream side of the weir, equal in length to twice the depth of the sheet piling. This upstream floor may be thin because the depth of water on the floor will more than balance the upward pressure on the under side of the floor. The main purpose of the lower cut off wall is to either give a sufficient length of enforced percolation, or to protect the lower end of the floor from undermining. If a sufficient length of enforced percolation can be obtained without the lower cut off wall, drain holes through the wall or at the lower end of the wall are advisable to decrease the uplift.

**Length of path of percolation.**

The path of percolation must be great enough to offer sufficient resistance to the underflow to prevent the undermining of the structure by the transportation or washing away of the material under the floor. The necessary length of enforced percolation is expressed by Bligh by the following equation:

$$l = C \times H$$

where $l$ = length or path of enforced percolation.

$H$ = head of water represented by maximum difference of elevation of water levels on the upstream and downstream side of the weir.

$C$ = coefficient depending on the character of the material. Bligh recommends the following values of C:

$C = 18$ for river beds of light silt and mud, as the Nile.

$C = 15$ for fine micaceous sand such as the Colorado River.

$C = 12$ for coarse grained sand.

$C = 9\text{-}5$ for boulders or shingle and gravel and sand mixed.

**Intensity of uplift pressure and thickness and weight of floor.**

The intensity of uplift pressure as previously considered, is the resultant of the upward pressure on the underface of the floor and the downward pressure due to the weight of the water on the upper face of the floor. The intensity of the resultant pressure head at the upper or inlet end of the path of percolation is equal to the head which produces the underflow, which is equal to the difference in elevation between the water levels on both sides of the weir. From this value (denoted by H) the intensity decreases along the path of percolation, and has a minimum value of zero at the outlet end of the path of percolation. The intensity of resultant uplift pressure at any point on the under face of the floor or at any point on the path of percolation is equal to $H - h$, where h represents the loss in head due to length of percolation to this point.

If $l$ = total length of path of percolation.

$l_1$ = length of path of percolation to point considered.

$p$ = intensity of resultant of uplift pressure in lbs. per square foot.

$C$ = coefficient on which length of percolation path is based.

$w_1$ = weight of a cubic foot of water.

$w_2$ = weight of a cubic foot of floor material.

$t$ = thickness of floor necessary to balance uplift.

Then $p = (H - h)w_1$; But $H/h = l/l_1$ and $l = HC$

$$\text{therefore, } h = \frac{Hl_1}{l} = \frac{Hl_1}{HC} = \frac{l_1}{C} \text{ and } p = \left(H - \frac{l_1}{C}\right)w_1$$

To balance the resultant uplift pressure the weight of the floor per square foot must at least equal the intensity of uplift pressure at this point; therefore,

$$w_2 t = H - \frac{l_1}{C} w_1 \text{ or } t = \left(H - \frac{l_1}{C}\right)\frac{W_1}{w_2} = \left(H - \frac{l_1}{C}\right)\frac{62.5}{w_2}$$

$w_2$ is the weight of the floor material, weighed in air, only when the surface of the tail water is lower than the under face of the floor. When the tail water covers the upper face of the floor, then the floor is submerged and $w_2$ must be the weight of the floor material weighed in water. When the surface of the tail water is at an elevation in between the under floor face and the upper floor face there is partial submergence only. For safety the thickness should be made about 1/3 greater than that required for exact balance; the equation is then:

$$t = \frac{4}{3}\left(H - \frac{l_1}{C}\right)\frac{62.5}{w_2} \quad \text{When floor is not submerged.}$$

$$t = \frac{4}{3}\left(H - \frac{l_1}{C}\right)\frac{62.5}{w_2 - 62.5} \quad \text{When floor is submerged.}$$

The minimum thickness of floor should not be less than 3 ft.

**Length of floor and cut off walls.**

The total length of the path of percolation is obtained as previously stated. This total length is divided up between the downstream floor, the cut off walls and in some cases an upstream floor. What proportion of it will go into the downstream floor itself depends on the impact of the falling water. Usually a length of floor, measured from the downstream toe of the weir wall, of 3 or 4 times the height of the weir crest above the floor, is sufficient. Mr. Bligh recommends the following empirical equation: Length of apron measured from downstream toe of weir wall = where C is the coefficient above referred to ranging

from 18 to 5 for different materials. $H_s$ = height of weir crest above the floor. Knowing the length of the floor this value subtracted from the total length of percolation, gives the length to be provided for by cut off walls or upstream floor.

**Length of riprap.**

The impervious floor is continued with riprap or paving. The length of this riprap depends on the character of the stream bed, the height of fall and the volume of water carried. Mr. Bligh recommends the following formula to obtain the total length of floor and riprap.

Where $H_b$ = the height of the weir crest above low water level on downstream side of weir wall.

9 = maximum flood discharge in cubic feet per second for lineal foot of weir crest.

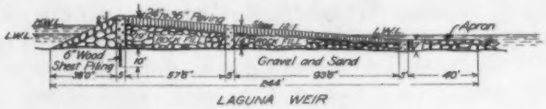
Therefore, the length of riprap will be $L_p = L - L_a = .355\ C \sqrt{H_b 9} - L_a$

The thickness of the riprap should not usually be less than two feet.

**Preparation of foundations for weirs built on pervious soils such as sand, gravel, cobbles, etc.**

The preparation of the foundation will depend on the type of weir. For this purpose they may be put in two classes: (1) the weirs which have a heavy floor and depend on their weight for their stability against upward pressure; (2) the weirs which have a light floor of lumber or reinforced concrete which must be held down to resist the upward pressure.

Weirs of the first class are constructed according to the principles considered for the design of gravity




floor and require no special preparation of the foundation, except a cut off wall at the upstream toe of the weir to increase the path of percolation and in some cases a cut-off wall at the downstream end of the floor to obstruct any movement of the bed under the floor and prevent undermining by underwash. Steel sheet piling or wooden sheet piling made of three thicknesses of lumber so as to form tongue and groove joints are generally used. Where sheet piling can not be driven because of cobbles or boulders, it may be necessary to excavate deep trenches and build concrete cut off walls or wooden apron embedded in concrete.

The second class of weirs requires rows of piles driven in the sand and connected to the weir superstructure and floor and cut off walls. The entire bearing surface is prepared with rows of piles 4 to 8 ft. apart. When the superstructure and floor is to be made of lumber the rows of piles are connected together with cross timbers which will form part of the structure. When reinforced concrete is used the steel reinforcement of the floor must be connected to the piles and cut off walls which should be preferably reinforced concrete piles and sheet piles. The depth of penetration of the piles will depend on the upward lift, and should be sufficient to offer enough friction resistance to overcome the uplift on the floor.

**References:**

1. Dams on Sand Foundations, by Arnold C. Koenig, Transactions of the American Society of Civil Engineers, Sept., 1911.
2. Weir Experiments, Coefficients, and Formulas, by Robert E. Horton, Water Supply and Irrigation Papers, No. 150, U. S. Geological Survey.
3. The Practical Design of Irrigation Works, by W. G. Bligh. Van Nostrand Co., New York, 1911.

## CONTRACTS AWARDED AT THE PANAMA-PACIFIC EXPOSITION.

The Buildings and Grounds Committee of the Panama-Pacific International Exposition, in a report just submitted to the board of directors, states that work in that department is progressing with great rapidity. The contract for filling Presidio lands will be completed by the Standard American Dredging Company within the next ten days. The construction of the Service Building will be completed before the first of February. The contract for the improvement of Fulton basin by the construction of docks, etc., has been awarded to Mercer, Fraser and Company. About one-half of the piles have been driven and caps for the wharves are being placed thereon. Contract for the construction of a roadway through Fort Mason is completed with the exception of the surfacing of the asphalt surface, which will be laid as soon as the weather permits, it being necessary to have dry weather to successfully lay asphalt. The contract for the construction of the South Garden sewers, awarded to Pringle, Dunn & Company, has been practically completed, as is also the grading of the site of the Machinery Building. Bids for the construction of the high pressure water system were received on January 28th. A contract for the construction of the sanitary and storm sewers in the State and Foreign Pavilion sites has been awarded to Michael Murphy for $28,350, and the contract will be signed within the next few days. The contract awarded to Palmer, McBride & Quayle for the preparation of gardens and courts is well under way and will probably be completed within the next ten days. The contract for the construction of Machinery Hall has been awarded to W. W. Anderson & Company, the contract price being $451,900. Bids have been received for the construction of the service water supply system, for the construction of the ferry slips and for the construction of a hydraulic power plant. Plans and specifications for the Educational Building are prepared and estimate of cost is being made. Contracts for the lumber for the Machinery Building, aggregating six and one-half million feet have been let at a cost of $113,000. Bids for the construction of steel apron and for ferry slips have been received.

## ELECTRIC OPERATIONS IN SIAM.

At the recent half-yearly meeting of the Siam Electricity Co. (Ltd.) the manager reported that the new three-phase plant had been completed; that the new turbines were running regularly, and that the station is now equipped with an up-to-date and economical generating plant of ample capacity. The lighting business has increased 44 per cent during the last two years. The usual dividend of 6 per cent was declared the first half year of 1912.

# TRANSFORMER CONNECTIONS[1]

BY W. A. HILLEBRAND AND E. R. SHEPARD.

With the extension and unification of power transmission systems a company frequently finds it necessary to furnish a miscellaneous service, single, two and three phase, 110, 220, 440, 550, 1100 and 2200 volts, applied to motors, and sometimes of more than one frequency. Distribution voltages, depending on distance and connected load, range from 1100 to 20,000.

To improve service on an overload feeder, it is, in general, cheaper to raise the voltage than to increase the amount of feeder copper, where the former can be accomplished without replacing existing equipment. In long-established territory it is often impracticable to adopt either two or three phases as standard or a limited range of secondary voltages, because of the amount of apparatus which the company would be obliged to replace at its own expense. These facts, together with the exigencies of reconstruction, temporary work and development of new territory, are often responsible for a resort to expedients, particularly in the way of transformer connections, which under ideal conditions might not be considered.

Accordingly, the present paper has been written for the purpose of collecting a number of the more important single and polyphase transformer diagrams and discussing the losses, regulation, and division of loads, in the hope that such a compendium may be of interest and value to the distribution engineer. Some of the material herein contained, which is printed for the sake of completeness, is common knowledge, readily available in hand-books and elsewhere, and still more is to be found in scattered articles throughout the literature, an incomplete list of which will be found at the end.

Fig. 1 illustrates the not infrequent practice in city distribution of paralleling two or more transformers at different points on a common secondary

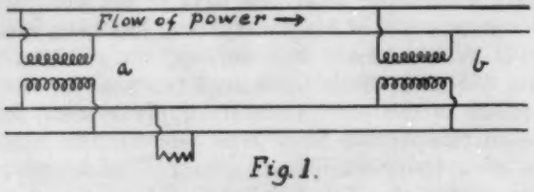



Fig. 1.

bus. Assuming the load concentrated at one point, the division of current can very readily be determined as follows:

$r_p$ resistance of primary circuit, a to b.
$x_p$ reactance of primary circuit, a to b.
$r_a'$ primary resistance, transformer a.
$r_a''$ secondary resistance, transformer a.
$x_a$ reactance, transformer a, measured on primary side.
$r_s'$ resistance secondary bus, a to load.
$x_s'$ reactance secondary bus, a to load.
$r_b'$ primary resistance, transformer b.
$r_b''$ secondary resistance, transformer b.
$x_b$ reactance, transformer b, measured on primary side.
$r_s''$ resistance of secondary bus, b to load.
$x_s''$ reactance of secondary bus, b to load.
n ratio of transformation.

There are two parallel circuits, one through transformer a to load, and the other through transformer b to load. Call these circuits A and B. Then, in terms of primary,

Resistance of circuit A $= R_a = r_a' + n^2 (r_a'' + r_s')$
Reactance of circuit A $= X_a = x_a + n^2 x_s'$
Impedance of circuit A $= R_a + jX_a$
Resistance of B $= R_b = r_p + r_b' + n^2 (r_b'' + r_s'')$
Reactance of B $= X_b = x_p + x_b + n^2 x_s''$
Impedance of B $= R_b + jX$

The impedance of the parallel circuit is

$$Z = \frac{(R_a + jX_a)\ (R_b + jX_b)}{(R_a + R_b) + j\ (X_a + X_b)}$$

If the load draws a current I in the primary, the impedance drop will be

$$e = ZI = \frac{(R_a + jX_a)\ (R_b + jX_b)}{(R_a + R_b) + j\ (X_a + X_b)} . I$$

The current in branch A is

$$i_a = \frac{e}{R_a + jX_a}$$

and in branch B

$$i_b = \frac{e}{R_b + jX_b}$$

These two currents will bear to each other the inverse ratio of their impedances. That is

$$\frac{i_a}{i_b} = \frac{R_b + jX_b}{R_a + jX_a}$$

and their arithmetic sum will not equal the total current I, but will in general be greater, due to the usually different power factors of the two circuits A and B. The vector representation is given in Fig. 2.

The excessive currents due to different power factors of the two branches become appreciable only when the ratio of resistance to reactance in one circuit is very high, and in the other very low. This might occur with load concentrated at a or b, in either of which cases the effect due to phase difference would

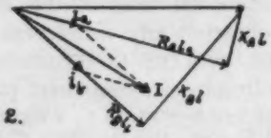



Fig. 2.

be swamped by the overloading due to disproportion in the impedance ratios, caused chiefly by the impedance of secondary bus. For this reason the question of phase displacement between the two branch currents is believed to be of only theoretical importance.

**Use of the transformers, i. e., potential transformesr, with primaries connected in series across a potential too high for either alone.**

Secondaries must be loaded as in Figs. 3 or 4. Loading as in Fig. 5 is not permissible, because the current drawn by the primary of transformer No. 1 must also pass through the primary of No. 2, which, having no neutralizing secondary ampere turns, now acts as a choke coil so that voltage across No. 1 will drop and correspondingly rise across No. 2.

An understanding of the behavior of transformers

[1]Paper presented before the Portland Section, A. I. E. E., January, 1913.

connected as in Fig. 5 and in open delta is of importance in appreciating the regulation and distribution of currents by the poly-phase connections which are subsequently discussed.

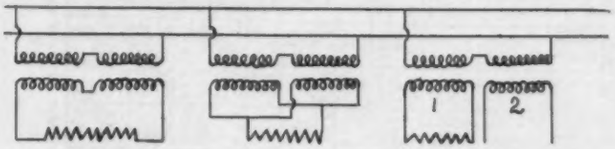



Fig. 3. Fig. 4 Fig. 5.

**Open Delta.**

With balanced, non-inductive load, the current in one transformer leads by 30 degrees, and the current in the other transformer lags by the same amount. Therefore, the combined capacity, based on temperature rise, is only 87 per cent of their combined capacity as single phase apparatus.

Due to the different power factors at which the two transformers operate they will regulate differently under load, that which carries the leading or high-power factor current suffering a smaller voltage drop than the other, with the result that voltages will unbalanced somewhat under load, although if the load itself is symmetrical, this unbalancing is not likely to be serious.

If single phase lighting is to be supplied, it should be connected as in Figs. 7 or 8, not as in Fig. 9.

When connected as in Fig. 9 both transformers must supply the single phase current, although one could do it equally as well with but half the loss. An additional objection to this connection arises from the fact that this single phase current leads the e.m.f. of one transformer by 60 degrees and lags behind that of the other by 60 degrees. These low power factor currents tend to aggravate the unbalancing at a time

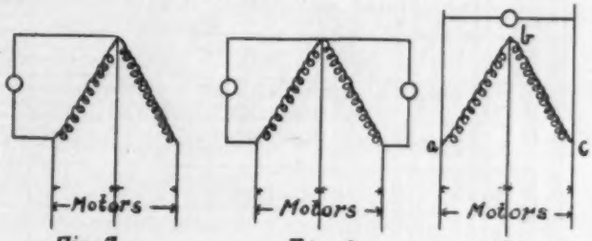



Fig. 7. Fig. 8. Fig 9.

when the transformers can probably least stand the additional currents drawn as a result therefrom by induction motors.

The practice is occasionally met with of distributing four-wire, three-phase, at 4000 or 11,000 volts, using 2200 or 6600-volt transformers, primaries Y connected and neutrals grounded. The transformers are cheaper than if built for line voltage, and the 4000-volt system with only 2300 volts to ground, can be worked hot. If one transformer fails, service can still be maintained by two transformers up to 57 per cent of the capacity of all three. However, if the ground connection rusts away or dries out, the high resistance drop will cause such voltage distortion under load as to leave motors inoperative. This difficulty is eliminated by stringing a fourth or neutral conductor, which may be satisfactorily grounded at water courses.

(To be continued.)

# READINESS TO SERVE METHODS

## RECLAIMED LANDS.

BY ROSS B. MATEER.

Not all the lands now yielding large returns per acre cultivated, were developed merely by the use of water for encouraging vegetation as much of the soil now commanding high prices in the Sacramento Valley was, only a few years ago, subject to overflow during periods of high water and possessed characteristics of a marsh during other portions of the year. This land may be classed under two divisions: (1) the lowlands; (2) the peat islands.

The first class includes those lands contiguous to the natural streams subject annually to overflow during periods when the snow is rapidly melting in the mountains, the fertility of which is dependent on the deposits of sand, silt, clay or gravel made possible by the gradual disintegration of rock.

Lands of this character yield a good return per acre where artificial means are used to control the flood and direct its path.

The second class, on the other hand, includes those lands affected by tidewater known as "tule" and the peat bogs, both of unsurpassed fertility when yielding to cultivation.

Soils of this character must be protected from flood and tide. This necessitates the construction of embankments, principally of sand, though often with clay or concrete cores. Quantities of material, gravel and clay, can only be deposited in the periods of low water. Hence, huge steam and electrically operated dredges are utilized twenty hours each day, throughout the long summer months, to build embankments some fifty feet in width at the base, twenty-four feet wide at the top and from twenty to thirty feet high, which, as a rule, surround a tract of from 400 to 11,000 acres.

These undertakings, beyond the reach of any one individual, are accomplished only by the formation of reclamation districts in which each land owner submits to an assessment per acre for purposes of providing funds to meet the interest and per cent of principal due annually on the bonds issued by the district, and comprising a prior lien on all land embraced within the huge earthen breastworks. The principal and interest of all bonds are guaranteed by the county.

**Reclamation Pumps.**

To prevent the rapid rise in water level within the reclaimed districts through seepage and flood, motor operated pumps, varying from 12-inch up to and including 48-inch diameter, are installed, each belted to motors of sufficient capacity to operate against a maximum head.

| SIZE OF PUMP | GALLONS DELIVERED PER MINUTE | REVOLUTIONS PER MINUTE | HORSEPOWER REQUIRED | SUCTION AND DISCHARGE | IRRIGATING DIRECT FROM PUMPS — ACRES IRRIGATED IN ONE HOUR | | | | | | IRRIGATING DIRECT FROM PUMPS — ACRES IRRIGATED IN TWELVE HOURS | | | | | | IRRIGATING DIRECT FROM PUMPS — ACRES IRRIGATED IN TWENTY FOUR HOURS | | | | | | SIZE OF RESERVOIR | | | | IRRIGATING FROM RESERVOIR — ACRES IRRIGATED IN ONE HOUR | | | | | | IRRIGATING FROM RESERVOIR — ACRES IRRIGATED IN TEN HOURS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1" DEEP | 2" DEEP | 3" DEEP | 4" DEEP | 6" DEEP | 8" DEEP | 1" DEEP | 2" DEEP | 3" DEEP | 4" DEEP | 6" DEEP | 8" DEEP | 1" DEEP | 2" DEEP | 3" DEEP | 4" DEEP | 6" DEEP | 8" DEEP | SIZE IN FEET | LENGTH WIDTH DEPTH | CAPACITY IN GALLONS | TIME REQUIRED TO FILL | 1" DEEP | 2" DEEP | 3" DEEP | 4" DEEP | 6" DEEP | 8" DEEP | 1" DEEP | 2" DEEP | 3" DEEP | 4" DEEP | 6" DEEP | 8" DEEP |
| 1 | 20 | 20 | 1740 | ¾ | .0305 | .015 | .010 | .0076 | .005 | .0038 | .366 | .183 | .122 | .0915 | .061 | .0457 | .732 | .366 | .244 | .183 | .122 | .0914 | .01 | 2'1"x2'1"x4' | 28800 | Hours 24 | .073 | .036 | .024 | .018 | .012 | .009 | .73 | .36 | .24 | .18 | .12 | .09 |
| 1 | 20 | 45 | 1740 | 1 | .0305 | .015 | .010 | .0076 | .005 | .0038 | .366 | .183 | .122 | .0915 | .061 | .0457 | .732 | .366 | .244 | .183 | .122 | .0914 | .01 | 2'1"x2'1"x4' | 28800 | 24 | .073 | .036 | .024 | .018 | .012 | .009 | .73 | .36 | .24 | .18 | .12 | .09 |
| 1 | 20 | 60 | 1740 | 1 | .0305 | .015 | .010 | .0076 | .005 | .0038 | .366 | .183 | .122 | .0915 | .061 | .0457 | .732 | .366 | .244 | .183 | .122 | .0914 | .01 | 2'1"x2'1"x4' | 28800 | 24 | .073 | .036 | .024 | .018 | .012 | .009 | .73 | .36 | .24 | .18 | .12 | .09 |
| 1½ | 50 | 20 | 1740 | 1 | .074 | .037 | .024 | .0185 | .012 | .009 | .89 | .445 | .293 | .223 | .148 | .11 | 1.78 | .89 | .586 | .445 | .296 | .22 | .055 | 5'0"x5'0"x4' | 72,000 | 24 | .177 | .089 | .0576 | .045 | .027 | .022 | 1.77 | .89 | .576 | .45 | .27 | .22 |
| 1½ | 50 | 45 | 1740 | 2 | .074 | .037 | .024 | .0185 | .012 | .009 | .89 | .445 | .293 | .223 | .148 | .11 | 1.78 | .89 | .586 | .445 | .296 | .22 | .055 | 5'0"x5'0"x4' | 72,000 | 24 | .177 | .089 | .0576 | .045 | .027 | .022 | 1.77 | .89 | .576 | .45 | .27 | .22 |
| 1½ | 50 | 60 | 1740 | 3 | .074 | .037 | .024 | .0185 | .012 | .009 | .89 | .445 | .293 | .223 | .148 | .11 | 1.78 | .89 | .586 | .445 | .296 | .22 | .055 | 5'0"x5'0"x4' | 72,000 | 24 | .177 | .089 | .0576 | .045 | .027 | .022 | 1.77 | .89 | .576 | .45 | .27 | .22 |
| 2 | 100 | 20 | 1740 | 2 | .15 | .075 | .05 | .037 | .025 | .0183 | 1.80 | .90 | .60 | .45 | .30 | .225 | 3.60 | 1.80 | 1.20 | .90 | .60 | .45 | .11 | 7'0"x7'0"x4' | 144000 | 24 | .36 | .18 | .12 | .09 | .06 | .044 | 3.60 | 1.80 | 1.20 | .89 | .60 | .44 |
| 2 | 100 | 45 | 1740 | 3 | .15 | .075 | .05 | .037 | .025 | .0183 | 1.80 | .90 | .60 | .45 | .30 | .225 | 3.60 | 1.80 | 1.20 | .90 | .60 | .45 | .11 | 7'0"x7'0"x4' | 144000 | 24 | .36 | .18 | .12 | .09 | .06 | .044 | 3.60 | 1.80 | 1.20 | .89 | .60 | .44 |
| 2 | 100 | 60 | 1740 | 5 | .15 | .075 | .05 | .037 | .025 | .0183 | 1.80 | .90 | .60 | .45 | .30 | .225 | 3.60 | 1.80 | 1.20 | .90 | .60 | .45 | .11 | 7'0"x7'0"x4' | 144000 | 24 | .36 | .18 | .12 | .09 | .06 | .044 | 3.60 | 1.80 | 1.20 | .89 | .60 | .44 |
| 2½ | 150 | 20 | 1120 | 2 | .225 | .112 | .075 | .056 | .037 | .028 | 2.70 | 1.35 | .90 | .675 | .45 | .337 | 5.4 | 2.70 | 1.80 | 1.35 | .90 | .674 | .17 | 8'5"x8'5"x4' | 216000 | 24 | .54 | .27 | .18 | .135 | .09 | .067 | 5.4 | 2.7 | 1.8 | 1.35 | .90 | .67 |
| 2½ | 150 | 35 | 1120 | 3 | .225 | .112 | .075 | .056 | .037 | .028 | 2.70 | 1.35 | .90 | .675 | .45 | .337 | 5.4 | 2.70 | 1.80 | 1.35 | .90 | .674 | .17 | 8'5"x8'5"x4' | 216000 | 24 | .54 | .27 | .18 | .135 | .09 | .067 | 5.4 | 2.7 | 1.8 | 1.35 | .90 | .67 |
| 2½ | 150 | 50 | 1740 | 5 | .225 | .112 | .075 | .056 | .037 | .028 | 2.70 | 1.35 | .90 | .675 | .45 | .337 | 5.4 | 2.70 | 1.80 | 1.35 | .90 | .674 | .17 | 8'5"x8'5"x4' | 216000 | 24 | .54 | .27 | .18 | .135 | .09 | .067 | 5.4 | 2.7 | 1.8 | 1.35 | .90 | .67 |
| 2½ | 150 | 60 | 1740 | 5 | .225 | .112 | .075 | .056 | .037 | .028 | 2.70 | 1.35 | .90 | .675 | .45 | .337 | 5.4 | 2.70 | 1.80 | 1.35 | .90 | .674 | .17 | 8'5"x8'5"x4' | 216000 | 24 | .54 | .27 | .18 | .135 | .09 | .067 | 5.4 | 2.7 | 1.8 | 1.35 | .90 | .67 |
| 2½ | 150 | 75 | 1740 | 7½ | .225 | .112 | .075 | .056 | .037 | .028 | 2.70 | 1.35 | .90 | .675 | .45 | .337 | 5.4 | 2.70 | 1.80 | 1.35 | .90 | .674 | .17 | 8'5"x8'5"x4' | 216000 | 24 | .54 | .27 | .18 | .135 | .09 | .067 | 5.4 | 2.7 | 1.8 | 1.35 | .90 | .67 |
| 3 | 225 | 20 | 850 | 3 | .34 | .17 | .113 | .085 | .056 | .042 | 4.08 | 2.04 | 1.36 | 1.02 | .68 | .51 | 8.16 | 4.08 | 2.72 | 2.04 | 1.36 | 1.11 | .23 | 10'4"x10'4"x4' | 324000 | 24 | .815 | .41 | .27 | .20 | .13 | .10 | 8.15 | 4.10 | 2.7 | 2.0 | 1.3 | 1.0 |
| 3 | 225 | 35 | 1120 | 5 | .34 | .17 | .113 | .085 | .056 | .042 | 4.09 | 2.04 | 1.36 | 1.02 | .68 | .51 | 8.16 | 4.08 | 2.72 | 2.04 | 1.36 | 1.11 | .23 | 10'4"x10'4"x4' | 324000 | 24 | .815 | .41 | .27 | .20 | .13 | .10 | 8.15 | 4.10 | 2.7 | 2.0 | 1.3 | 1.0 |
| 3 | 225 | 50 | 1740 | 7½ | .34 | .17 | .113 | .085 | .056 | .042 | 4.08 | 2.04 | 1.36 | 1.02 | .68 | .51 | 8.16 | 4.08 | 2.72 | 2.04 | 1.36 | 1.11 | .23 | 10'4"x10'4"x4' | 324000 | 24 | .815 | .41 | .27 | .20 | .13 | .10 | 8.15 | 4.10 | 2.7 | 2.0 | 1.3 | 1.0 |
| 3 | 225 | 60 | 1740 | 7½ | .34 | .17 | .113 | .085 | .056 | .042 | 4.08 | 2.04 | 1.36 | 1.08 | .68 | .51 | 8.16 | 4.09 | 2.72 | 2.04 | 1.36 | 1.11 | .23 | 10'4"x10'4"x4' | 324000 | 24 | .815 | .41 | .27 | .20 | .13 | .10 | 8.15 | 4.10 | 2.7 | 2.0 | 1.3 | 1.0 |
| 3 | 225 | 75 | 1740 | 10 | .34 | .17 | .113 | .085 | .056 | .042 | 4.08 | 2.04 | 1.36 | 1.08 | .68 | .51 | 8.16 | 4.08 | 2.72 | 2.04 | 1.36 | 1.11 | .23 | 10'4"x10'4"x4' | 324000 | 24 | .815 | .41 | .27 | .20 | .13 | .10 | 8.15 | 4.10 | 2.7 | 2.0 | 1.3 | 1.0 |
| 3½ | 300 | 20 | 850 | 5 | .44 | .22 | .146 | .11 | .073 | .055 | 5.39 | 2.69 | 1.79 | 1.35 | .898 | .673 | 10.78 | 5.38 | 3.58 | 2.70 | 1.80 | 1.34 | .33 | 12'1"x12'1"x4' | 432000 | 24 | 1.05 | .53 | .35 | .26 | .17 | .13 | 10.5 | 5.3 | 3.5 | 2.6 | 1.7 | 1.3 |
| 3½ | 300 | 35 | 1120 | 7½ | .44 | .22 | .146 | .11 | .073 | .055 | 5.39 | 2.69 | 1.79 | 1.35 | .898 | .673 | 10.78 | 5.38 | 3.58 | 2.70 | 1.80 | 1.34 | .33 | 12'1"x12'1"x4' | 432000 | 24 | 1.05 | .53 | .35 | .26 | .17 | .13 | 10.5 | 5.3 | 3.5 | 2.6 | 1.7 | 1.3 |
| 3½ | 300 | 50 | 1740 | 10 | .44 | .22 | .146 | .11 | .073 | .055 | 5.39 | 2.69 | 1.79 | 1.35 | .898 | .673 | 10.78 | 5.38 | 3.58 | 2.70 | 1.80 | 1.34 | .33 | 12'1"x12'1"x4' | 432000 | 24 | 1.05 | .53 | .35 | .26 | .17 | .13 | 10.5 | 5.3 | 3.5 | 2.6 | 1.7 | 1.3 |
| 3½ | 300 | 60 | 1740 | 10 | .44 | .22 | .146 | .11 | .073 | .055 | 5.39 | 2.69 | 1.79 | 1.35 | .898 | .673 | 10.78 | 5.38 | 3.58 | 2.70 | 1.80 | 1.34 | .33 | 12'1"x12'1"x4' | 432000 | 24 | 1.05 | .53 | .35 | .26 | .17 | .13 | 10.5 | 5.3 | 3.5 | 2.6 | 1.7 | 1.3 |
| 3½ | 300 | 75 | 1740 | 15 | .44 | .22 | .146 | .11 | .073 | .055 | 5.39 | 2.69 | 1.79 | 1.35 | .898 | .673 | 10.78 | 5.38 | 3.58 | 2.70 | 1.80 | 1.34 | .33 | 12'1"x12'1"x4' | 432000 | 24 | 1.05 | .53 | .35 | .26 | .17 | .13 | 10.5 | 5.3 | 3.5 | 2.6 | 1.7 | 1.3 |
| 4 | 400 | 20 | 850 | 5 | .61 | .305 | .20 | .15 | .10 | .075 | 7.35 | 3.67 | 2.45 | 1.84 | 1.225 | .98 | 14.70 | 7.34 | 4.90 | 3.68 | 2.45 | 1.84 | .44 | 13'9"x13'9"x4' | 576000 | 24 | 1.46 | .73 | .48 | .36 | .24 | .18 | 14.6 | 7.3 | 4.8 | 3.6 | 2.4 | 1.8 |
| 4 | 400 | 35 | 1120 | 7½ | .61 | .305 | .20 | .15 | .10 | .075 | 7.35 | 3.67 | 2.45 | 1.84 | 1.225 | .98 | 14.70 | 7.34 | 4.90 | 3.68 | 2.45 | 1.84 | .44 | 13'9"x13'9"x4' | 576000 | 24 | 1.46 | .73 | .48 | .36 | .24 | .18 | 14.6 | 7.3 | 4.8 | 3.6 | 2.4 | 1.8 |
| 4 | 400 | 50 | 1120 | 10 | .61 | .305 | .20 | .15 | .10 | .075 | 7.35 | 3.67 | 2.45 | 1.84 | 1.225 | .98 | 14.70 | 7.34 | 4.90 | 3.68 | 2.45 | 1.84 | .44 | 13'9"x13'9"x4' | 576000 | 24 | 1.46 | .73 | .48 | .36 | .24 | .18 | 14.6 | 7.3 | 4.8 | 3.6 | 2.4 | 1.8 |
| 4 | 400 | 60 | 1120 | 15 | .61 | .305 | .20 | .15 | .10 | .075 | 7.35 | 3.67 | 2.45 | 1.84 | 1.225 | .98 | 14.70 | 7.34 | 4.90 | 3.68 | 2.45 | 1.84 | .44 | 13'9"x13'9"x4' | 576000 | 24 | 1.46 | .73 | .48 | .36 | .24 | .18 | 14.6 | 7.3 | 4.8 | 3.6 | 2.4 | 1.8 |
| 4 | 400 | 75 | 1120 | 15 | .61 | .305 | .20 | .15 | .10 | .075 | 7.35 | 3.67 | 2.45 | 1.84 | 1.225 | .98 | 14.70 | 7.34 | 4.90 | 3.68 | 2.45 | 1.84 | .44 | 13'9"x13'9"x4' | 576000 | 24 | 1.46 | .73 | .48 | .36 | .24 | .18 | 14.6 | 7.3 | 4.8 | 3.6 | 2.4 | 1.8 |
| 5 | 700 | 20 | 850 | 7½ | 1.08 | .54 | .36 | .27 | .18 | .135 | 13.0 | 6.5 | 4.3 | 3.25 | 2.16 | 1.62 | 26.0 | 13.0 | 8.6 | 6.50 | 5.32 | 3.24 | .77 | 18'4"x18'4"x4' | 1008000 | 24 | 2.6 | 1.3 | .86 | .65 | .43 | .32 | 26.4 | 13.0 | 8.6 | 6.5 | 4.3 | 3.2 |
| 5 | 600 | 35 | 1120 | 10 | .98 | .46 | .306 | .23 | .153 | .115 | 11.04 | 5.52 | 3.68 | 2.76 | 1.84 | 1.38 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | .66 | 17'0"x17'0"x4' | 864000 | 24 | 2.2 | 1.1 | .73 | .55 | .36 | .27 | 22.0 | 11.0 | 7.3 | 5.5 | 3.6 | 2.7 |
| 5 | 600 | 50 | 1120 | 15 | .98 | .46 | .306 | .23 | .153 | .115 | 11.04 | 5.52 | 3.68 | 2.76 | 1.84 | 1.38 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | .66 | 17'0"x17'0"x4' | 864000 | 24 | 2.2 | 1.1 | .73 | .55 | .36 | .27 | 22.0 | 11.0 | 7.3 | 5.5 | 3.6 | 2.7 |
| 5 | 700 | 60 | 1120 | 20 | 1.08 | .54 | .36 | .27 | .18 | .135 | 13.0 | 6.5 | 4.3 | 3.25 | 2.16 | 1.62 | 26.0 | 13.0 | 8.6 | 6.50 | 5.32 | 3.24 | .77 | 18'4"x18'4"x4' | 1008000 | 24 | 2.6 | 1.3 | .86 | .65 | .43 | .32 | 26.4 | 13.0 | 8.6 | 6.5 | 4.3 | 3.2 |
| 5 | 700 | 75 | 1120 | 25 | 1.08 | .54 | .36 | .27 | .18 | .135 | 13.0 | 6.5 | 4.3 | 3.25 | 2.16 | 1.62 | 26.0 | 13.0 | 8.6 | 6.50 | 5.32 | 3.24 | .77 | 18'4"x18'4"x4' | 1008000 | 24 | 2.6 | 1.3 | .86 | .65 | .43 | .32 | 26.4 | 13.0 | 8.6 | 6.5 | 4.3 | 3.2 |
| 6 | 900 | 20 | 850 | 10 | 1.36 | .68 | .496 | .34 | .243 | .17 | 16.4 | 8.2 | 5.46 | 4.10 | 2.73 | 2.5 | 32.8 | 16.4 | 11.92 | 8.20 | 5.32 | 5.00 | 1.00 | 20'8"x20'8"x4' | 1296000 | 24 | 3.26 | 1.63 | 1.08 | .81 | .54 | .40 | 32.6 | 16.3 | 10.8 | 8.10 | 5.4 | 4.0 |
| 6 | 900 | 35 | 1120 | 15 | 1.36 | .68 | .496 | .34 | .243 | .17 | 16.4 | 8.2 | 5.46 | 4.10 | 2.73 | 2.5 | 32.8 | 16.4 | 11.92 | 8.20 | 5.32 | 4.10 | 1.00 | 20'8"x20'8"x4' | 1296000 | 24 | 3.26 | 1.63 | 1.08 | .81 | .54 | .40 | 32.6 | 16.3 | 10.8 | 8.10 | 5.4 | 4.0 |
| 6 | 900 | 50 | 1120 | 20 | 1.36 | .68 | .496 | .34 | .243 | .17 | 16.4 | 8.2 | 5.46 | 4.10 | 2.73 | 2.5 | 32.8 | 16.4 | 11.92 | 8.20 | 5.32 | 4.10 | 1.00 | 20'8"x20'8"x4' | 1296000 | 24 | 3.26 | 1.63 | 1.08 | .81 | .54 | .40 | 32.6 | 16.3 | 10.8 | 8.10 | 5.4 | 4.0 |
| 6 | 900 | 60 | 1120 | 25 | 1.36 | .68 | .496 | .34 | .243 | .17 | 16.4 | 8.2 | 5.46 | 4.10 | 2.73 | 2.5 | 32.8 | 16.4 | 11.92 | 8.20 | 5.32 | 4.10 | 1.00 | 20'8"x20'8"x4' | 1296000 | 24 | 3.26 | 1.63 | 1.08 | .81 | .54 | .40 | 32.6 | 16.3 | 10.8 | 8.10 | 5.4 | 4.0 |
| 6 | 900 | 75 | 1120 | 35 | 1.36 | .68 | .496 | .34 | .243 | .17 | 16.4 | 8.2 | 5.46 | 4.10 | 2.73 | 2.5 | 32.8 | 16.4 | 11.92 | 8.20 | 5.32 | 4.10 | 1.00 | 20'8"x20'8"x4' | 1296000 | 24 | 3.26 | 1.63 | 1.08 | .81 | .54 | .40 | 32.6 | 16.3 | 10.8 | 8.10 | 5.4 | 4.0 |
| 7 | 1200 | 20 | 695 | 10 | 1.84 | .92 | .613 | .46 | .306 | .23 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | 44.16 | 22.08 | 14.72 | 11.04 | 6.76 | 5.52 | 1.38 | 24'0"x24'0"x4' | 1728000 | 24 | 4.41 | 2.2 | 1.47 | 1.10 | .73 | .55 | 44.1 | 22.0 | 14.7 | 11.0 | 7.3 | 5.5 |
| 7 | 1200 | 35 | 850 | 15 | 1.84 | .92 | .613 | .46 | .306 | .23 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | 44.16 | 22.08 | 14.72 | 11.04 | 6.76 | 5.52 | 1.38 | 24'0"x24'0"x4' | 1728000 | 24 | 4.41 | 2.2 | 1.47 | 1.10 | .73 | .55 | 44.1 | 22.0 | 14.7 | 11.0 | 7.3 | 5.5 |
| 7 | 1200 | 50 | 850 | 25 | 1.84 | .92 | .613 | .46 | .306 | .23 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | 44.16 | 22.08 | 14.72 | 11.04 | 6.76 | 5.52 | 1.38 | 24'0"x24'0"x4' | 1728000 | 24 | 4.41 | 2.2 | 1.47 | 1.10 | .73 | .55 | 44.1 | 22.0 | 14.7 | 11.0 | 7.3 | 5.5 |
| 7 | 1200 | 60 | 850 | 30 | 1.84 | .92 | .613 | .46 | .306 | .23 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | 44.16 | 22.08 | 14.72 | 11.04 | 6.76 | 5.52 | 1.38 | 24'0"x24'0"x4' | 1728000 | 24 | 4.41 | 2.2 | 1.47 | 1.10 | .73 | .55 | 44.1 | 22.0 | 14.7 | 11.0 | 7.3 | 5.5 |
| 7 | 1200 | 75 | 850 | 40 | 1.84 | .92 | .613 | .46 | .306 | .23 | 22.08 | 11.04 | 7.36 | 5.52 | 3.68 | 2.76 | 44.16 | 22.08 | 14.72 | 11.04 | 6.76 | 5.52 | 1.38 | 24'0"x24'0"x4' | 1728000 | 24 | 4.41 | 2.2 | 1.47 | 1.10 | .73 | .55 | 44.1 | 22.0 | 14.7 | 11.0 | 7.3 | 5.5 |
| 8 | 1600 | 80 | 695 | 15 | 2.38 | 1.19 | .76 | .59 | .38 | .295 | 28.6 | 14.30 | 9.50 | 7.15 | 4.76 | 3.57 | 57.2 | 28.6 | 19.0 | 14.30 | 9.52 | 7.14 | 1.77 | 27'8"x27'8"x4' | 2304000 | 24 | 5.71 | 2.85 | 1.90 | 1.42 | .95 | .71 | 57.1 | 28.5 | 19.0 | 14.2 | 9.5 | 7.1 |
| 8 | 1600 | 35 | 695 | 20 | 2.38 | 1.19 | .76 | .59 | .38 | .295 | 28.6 | 14.30 | 9.50 | 7.15 | 4.76 | 3.57 | 57.2 | 28.6 | 19.0 | 14.30 | 9.52 | 7.14 | 1.77 | 27'8"x27'8"x4' | 2304000 | 24 | 5.71 | 2.85 | 1.90 | 1.42 | .95 | .71 | 57.1 | 28.5 | 19.0 | 14.2 | 9.5 | 7.1 |
| 8 | 1600 | 50 | 850 | 30 | 2.38 | 1.19 | .76 | .59 | .38 | .295 | 28.6 | 14.30 | 9.50 | 7.15 | 4.76 | 3.57 | 57.2 | 28.6 | 19.0 | 14.30 | 9.52 | 7.14 | 1.77 | 27'8"x27'8"x4' | 2304000 | 24 | 5.71 | 2.85 | 1.90 | 1.42 | .95 | .71 | 57.1 | 28.5 | 19.0 | 14.2 | 9.5 | 7.1 |
| 8 | 1600 | 60 | 850 | 40 | 2.38 | 1.19 | .76 | .59 | .38 | .295 | 28.6 | 14.30 | 9.50 | 7.15 | 4.76 | 3.57 | 57.2 | 28.6 | 19.0 | 14.30 | 9.52 | 7.14 | 1.77 | 27'8"x27'8"x4' | 2304000 | 24 | 5.71 | 2.85 | 1.90 | 1.42 | .95 | .71 | 57.1 | 28.5 | 19.0 | 14.2 | 9.5 | 7.1 |
| 8 | 1600 | 75 | 850 | 50 | 2.38 | 1.19 | .76 | .59 | .38 | .295 | 28.6 | 14.30 | 9.50 | 7.15 | 4.76 | 3.57 | 57.2 | 28.6 | 19.0 | 14.30 | 9.52 | 7.14 | 1.77 | 27'8"x27'8"x4' | 2304000 | 24 | 5.71 | 2.85 | 1.90 | 1.42 | .95 | .71 | 57.1 | 28.5 | 19.0 | 14.2 | 9.5 | 7.1 |
| 10 | 2500 | 20 | 565 | 20 | 3.78 | 1.87 | 1.26 | .945 | .63 | .472 | 45.36 | 22.68 | 15.12 | 11.34 | 7.56 | 5.67 | 90.72 | 45.36 | 30.24 | 22.68 | 15.12 | 11.34 | 2.76 | 34'7"x34'7"x4' | 3600000 | 24 | 8.97 | 4.48 | 2.99 | 2.24 | 1.49 | 1.12 | 89.7 | 44.8 | 29.9 | 22.4 | 14.9 | 11.2 |
| 10 | 2500 | 35 | 695 | 30 | 3.78 | 1.89 | 1.26 | .945 | .63 | .472 | 45.36 | 22.68 | 15.12 | 11.34 | 7.56 | 5.67 | 90.72 | 45.36 | 30.24 | 22.68 | 15.12 | 11.34 | 2.76 | 34'7"x34'7"x4' | 3600000 | 24 | 8.97 | 4.48 | 2.99 | 2.24 | 1.49 | 1.12 | 89.7 | 44.8 | 29.9 | 22.4 | 14.9 | 11.2 |
| 10 | 2500 | 50 | 695 | 50 | 3.78 | 1.89 | 1.26 | .945 | .63 | .472 | 45.36 | 22.68 | 15.12 | 11.34 | 7.56 | 5.67 | 90.72 | 45.36 | 30.24 | 22.68 | 15.12 | 11.34 | 2.76 | 34'7"x34'7"x4' | 3600000 | 24 | 8.97 | 4.48 | 2.99 | 2.24 | 1.49 | 1.12 | 89.7 | 44.8 | 29.9 | 22.4 | 14.9 | 11.2 |
| 10 | 2500 | 60 | 695 | 60 | 3.78 | 1.89 | 1.26 | .945 | .63 | .472 | 45.36 | 22.68 | 15.12 | 11.34 | 7.56 | 5.67 | 90.72 | 45.36 | 30.24 | 22.68 | 15.12 | 11.34 | 2.76 | 34'7"x34'7"x4' | 3600000 | 24 | 8.97 | 4.48 | 2.99 | 2.24 | 1.49 | 1.12 | 89.7 | 44.8 | 29.9 | 22.4 | 14.9 | 11.2 |
| 10 | 2500 | 75 | 850 | 75 | 3.78 | 1.89 | 1.26 | .945 | .63 | .472 | 45.36 | 22.68 | 15.12 | 11.34 | 7.56 | 5.67 | 90.72 | 45.36 | 30.24 | 22.68 | 15.12 | 11.34 | 2.76 | 34'7"x34'7"x4' | 3600000 | 24 | 8.97 | 4.48 | 2.99 | 2.24 | 1.49 | 1.12 | 89.7 | 44.8 | 29.9 | 22.4 | 14.9 | 11.2 |
| 12 | 3500 | 20 | 565 | 25 | 5.28 | 2.64 | 1.76 | 1.32 | .88 | .66 | 63.4 | 31.71 | 21.14 | 15.85 | 10.57 | 7.92 | 126.8 | 63.4 | 42.28 | 31.7 | 21.14 | 15.64 | .385 | 40'4"x40'4"x4' | 5040000 | 24 | 12.67 | 6.33 | 4.22 | 3.16 | 2.11 | 1.58 | 126.7 | 63.3 | 42.2 | 31.6 | 21.1 | 15.8 |
| 12 | 3500 | 35 | 565 | 50 | 5.28 | 2.64 | 1.76 | 1.32 | .88 | .66 | 63.4 | 31.71 | 21.14 | 15.85 | 10.57 | 7.92 | 126.8 | 63.4 | 42.28 | 31.7 | 21.14 | 15.64 | .385 | 40'4"x40'4"x4' | 5040000 | 24 | 12.67 | 6.33 | 4.22 | 3.16 | 2.11 | 1.58 | 126.7 | 63.3 | 42.2 | 31.6 | 21.1 | 15.8 |
| 12 | 3500 | 50 | 695 | 60 | 5.28 | 2.64 | 1.76 | 1.32 | .88 | .66 | 63.4 | 31.71 | 21.14 | 15.85 | 10.57 | 7.92 | 126.8 | 63.4 | 42.28 | 31.7 | 21.14 | 15.64 | .385 | 40'4"x40'4"x4' | 5040000 | 24 | 12.67 | 6.33 | 4.22 | 3.16 | 2.11 | 1.58 | 126.7 | 63.3 | 42.2 | 31.6 | 21.1 | 15.8 |
| 12 | 3500 | 60 | 695 | 75 | 5.28 | 2.64 | 1.76 | 1.32 | .88 | .66 | 63.4 | 31.71 | 21.14 | 15.85 | 10.57 | 7.92 | 126.8 | 63.4 | 42.28 | 31.7 | 21.14 | 15.64 | .385 | 40'4"x40'4"x4' | 5040000 | 24 | 12.67 | 6.33 | 4.22 | 3.16 | 2.11 | 1.58 | 126.7 | 63.3 | 42.2 | 31.6 | 21.1 | 15.8 |
| 12 | 3500 | 75 | 850 | 100 | 5.28 | 2.64 | 1.76 | 1.32 | .88 | .66 | 63.4 | 31.71 | 21.14 | 15.85 | 10.57 | 7.92 | 126.8 | 63.4 | 42.28 | 31.7 | 21.14 | 15.64 | .385 | 40'4"x40'4"x4' | 5040000 | 24 | 12.67 | 6.33 | 4.22 | 3.16 | 2.11 | 1.58 | 126.7 | 63.3 | 42.2 | 31.6 | 21.1 | 15.8 |

NOTE - CAPACITY OF RESERVOIR EQUALS 24 TIMES SAME PUMP CAPACITY DISCHARGING DIRECT INTO THE DITCHES. PUMP DISCHARGING INTO RESERVOIR CONTINUOUSLY FOR 24 HOURS.

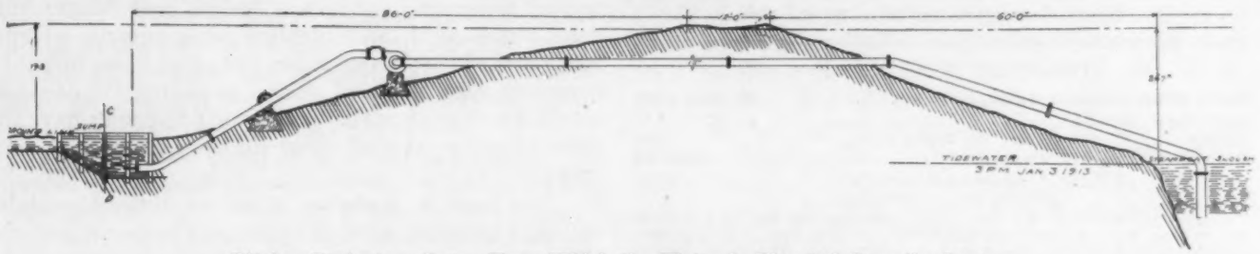
**Table of Irrigation Data Showing 70% of Theoretical Quantity to Allow for Losses. — Compiled by United Iron Works.**

The land is provided with ditches which drain to a low spot or sump, in which, is placed the suction pipe of the pump.

From the sump, the water is elevated over the levee and discharged into the slough or drain ditch which parallels the levee.

### Operating Cost.

Operating costs vary with seepage conditions. Where only floods are to be feared, the installations are from 75 to 100 h.-p., and the annual cost, except in extreme wet weather, will not exceed $900 to $1,200 where motor-drive is used, or $1,500 to $2,250 where oil is used as fuel, and reciprocating engine type units employed to operate the pumps.




Ditches Drain to a Sump, From Which the Water Is Elevated Over the Levee.

The expenses of such equipments include those of an engineer, a fireman, fuel and items incident to repairs, aggregating from $15.00 to $18.00 per annum on installations of 100 h.-p.

Recent activity on the part of power companies has resulted in many motor-operated equipments supplanting the steam apparatus, not alone by reason of decreased annual expense, but also by reason of flexibility in pumping units, combined with the simplicity of operation not possessed by other forms of power.

A recent change affected one of the oldest reclammation plants in point of service. The original installation consisting of a 26-inch Byron Jackson Centrifugal pump, coupled to an engine of 125 h.-p., was replaced with two pumps, each of 12-inch diameter, and a capacity of 4,500 gallons per minute, belted to motors of 75 h.-p., 2,000 volts, polyphase type.

Under ordinary conditions, one pump, operating 24 hours a day in wet seasons, will suffice to prevent overflow on the 420 acres comprising the district. The second pump constitutes reserve which increases the pumping capacity to 9,000 gallons per minute, under a head of 22 feet, should accident to the levee result in a rapid inrush of water. The installation of the new pumping plant, complete, will not exceed $4,500, or an assessment of $11.25 per acre, with an estimated maximum operating expense, based on previous years pumping, of $900, or $2.25 per acre, compared with the expense of $3.75 with steam. An economy of $1.50 per acre.

Comparison of operating expenses per h.-p. installed, show that the cost of steam equipment ranges from $15 to $18, while that of motor operated pumps, gives an average in this case of $6 per h.-p., or an economy of from $9 to $12 per annum, per h.-p. installed, over that of steam operated pumps.

Analysis of the operating costs, indicate that much of the saving is the result of fuel economy, labor and miscellaneous expense.

The motor may be placed in service by the throwing of a switch, and requires a minimum of attendance throughout the period of operation. The expense ceases where the water is below the ground level—eliminating standby steam losses and attendance. Proper design and fewer moving parts minimize the expense incident to repairs.

Many thousand acres, ranging in value from $250 to $800 per acre, and yielding abundant crops of fruit and alfalfa, are today under cultivation in the tule and peat islands of the Sacramento River, as a result of the motor-operated reclamation equipments used to throw excess seepage and flood waters over the protecting levee into the slough.

## CONSULTING ENGINEERS COMPLAIN OF NEW YORK PUBLIC SERVICE COMMISSION.

The American Institute of Consulting Engineers has issued a circular giving the text of a letter to the Governor of New York regarding the fact that no engineers are acting on the New York Public Service Commission. They urge the appointment of such Commissioners independent of political or other pressure, and secondly, to appoint men of engineering training selected from a list of, say, a dozen men to be submitted by the presidents of the five National engineering societies in co-operation with the presidents of the Chamber of Commerce and The Merchants' Association.

## LEADING NATURAL PRODUCTS OF THE UNITED STATES.

| PRODUCT | 1902 Quantity | 1902 Value | 1911 Quantity | 1911 Value |
|---|---|---|---|---|
| **Fuels—** | | | | |
| Bituminous coal (j), short tons | 260,216,844 | $290,858,483 | 405,757,101 | $451,177,484 |
| Pennsylvania Anthracite, long tons | 36,940,710 | 76,173,586 | 80,771,488 | 175,189,392 |
| Natural gas | ..... | 30,867,863 | ..... | 74,127,534 |
| Petroleum, barrels (42 gallons) | 88,766,916 | 71,178,910 | 220,449,391 | 134,044,752 |
| Peat | ..... | ..... | ..... | 272,114 |
| **Metals—** | | | | |
| Pig iron (a) (spot value b), long tons | 17,821,307 | 372,775,000 | 23,257,288 | 327,334,624 |
| Copper (e), value at New York City, pounds | 659,508,644 | 76,568,954 | 1,097,232,749 | 137,154,092 |
| **Structural Materials—** | | | | |
| Clay products (k) | ..... | 122,169,531 | ..... | 162,236,181 |
| Cement, barrels (380 lbs. net) | 25,753,504 | 25,366,380 | 79,547,958 | 66,705,136 |
| Stone (l) | ..... | 54,798,682 | ..... | 77,108,567 |

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POWER AND GAS

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### The Order for Joint Service

Scarcely seventy years have passed since the first railroad bridge was thrown across the Alleghany River. This bridge brought together tracks from Philadelphia and Ohio. It brought them together but could not join them, for the Pennsylvania state legislature had decreed that their gauges be different, fearing that local rolling stock might wander out of sight and lose itself.

How vastly broadened has become the horizon of utility regulation within the life of but one man! During the past week, for instance, a noteworthy decision has been handed down by the California Railroad Commission. The commission virtually rules that not alone should broad gauge ideas be infused among competing carriers of freight and human burdens, but even in those utilities conveying the weightless tones of the human voice, the same ideas of public necessity must have full sway. In a word the commission holds that unrelated telephone companies have the right to call upon each other for the exchange of messages.

The case in question arose upon the complaint of the Tehama County Telephone Company and the Glenn County Telephone Company in Northern California against the Pacific Telephone Company. The complaining companies desired to connect with the Pacific, so as to enable their patrons to use the long distance service of the Pacific company. The Pacific company declined to afford the connection and hence the case was brought to the commission. As noted above the commission finds that public convenience requires that the physical connection be made and that the complaining companies should stand the expense. The commission finds further that the telephone companies should arrange for a just division among themselves of the rates, tolls and charges, and if unable to do so within twenty days the commission itself will act in the matter.

The entire controversy embodies a new departure in regulation. It is seen at once to have far-reaching ramifications. For instance, a power company serving a community, may, upon this same principle, be allowed to make a physical connection with its competitor even though it be done against the will of its competitor. Thus a struggling, single-plant central station operating within reach of a network of a competing company may at once derive the stability and continuity of service to be realized from synchronous physical connection. Such a possibility is not to be deplored, however, for it is truly founded on principles of equity and justice. Moreover, the great majority of such possibilities are even now taken advantage of by mutual consent of both parties to the issue throughout the West. When a scientific rate based upon costs of continuity of service is thereby charged for such power as may be used, the public benefits immeasurably and the utility companies suffer not at all. Indeed it is the inevitable law of utility growth that where continuity of service is assured the usefulness of the product of the utility becomes proportionately broadened.

To cite a concrete instance it is evident that if anyone residing in San Francisco formerly desired to speak with a party situated on the Tehama lines,

upon being told that a messenger would have to be called to deliver the service or that it would be necessary to transmit it to the party desired, the chances are strong that either the mails or the telegraph company would reap the fee. A broader instance is that of interchange of mails in foreign service. Long series of checking indicate that both parties benefit in about the same proportion.

Each day in the evolution of utility regulation broad gauge men come more and more to the realization that maximum service at minimum cost, like Portia's dream of mercy, "blesseth him that gives and him that takes." It is a thoroughly recognized principle among advanced thinkers that a utility company is entitled to a reasonable return on the legitimate costs of service, and that the public is in return entitled to the very best commodity the utility by any possible combination can furnish. The joint service order, then, should be accepted as a reasonable, rational, new departure in utility regulation.

The principle being a new and untried one, an injustice may possibly in this instance and indeed in other applications be brought to one or the other of the companies joining in such physical connection. The commission in its wisdom has provided that, if the companies themselves cannot agree upon a just division of the tolls, it will fix the rates. It is certainly due the companies at issue, that this matter be given the most scientific readjustment possible, in order that no undue advantage be given a competing company under such an order.

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**Reclamation of Submerged Lands**

The dykes of Holland and the traditions which have grown up in that country since their formation are known the world over. The fertility of the soil there to be found is recognized as wholly accountable for the fact that in the Netherlands today exist more human souls to the square mile than in any other country on earth. Only in the last two or three years have agriculturists come to a realiaztion of the possible reduplication of this European feat upon a hitherto untouched empire in certain submerged portions of the West. The actual harvests gathered since the construction of the Laguna dam and the 73 miles of levees in the Colorado-Yuma project have indeed given emphasis to this possibility. The happy, smiling faces of contented families now dwelling upon lands in this reclamation project, where formerly human existence was impossible, forcefully add their evidence.

Each day brings to light similar possibilities in other parts of the West. Our leading article of this issue interestingly describes what is being accomplished at Isleton, situated in the heart of the delta of the Sacramento and San Joaquin rivers in the great central basin of California. The reclamation here taking place is of course interesting to all citizens of the West, for acreages by thousands are being brought from submerged tule lands to highly intensified farming possibilities. Since electric power is, however, largely responsible for this transformation, the subject is of especial interest to the hydroelectric fraternity.

In usual instances, irrigable lands take power only as a summer load. Here, however, it is found that in these countless reclaimed islands even the same pumps which operate to lift waters for irrigation are reversed in operation during a considerable portion of the remaining months of the year to keep the waters away from the flooded lands. In some cases where the lands are lower than the river waters power is not necessary to accomplish this reversal. Thus, at the Ryde plant during the summer months, when irrigation becomes necessary, the motor is disconnected, the discharge line is primed through a by-pass to the vacuum pump and water is then siphoned in from the river, as the pump runner is then forced to revolve freely in the reverse direction, thereby acting as a turbine.

Another interesting feature among the districts formed in these islands is the fact that, although as a rule the reclamation season lasts from December to April and the irrigation season from June to October, still in exceptional cases far different service is demanded. In 1911-12, for instance, no reclamation pumping was necessary at all, while in 1910-11 continuous operation was imperative. Indeed, the anomalous condition often exists of reclamation pumping and irrigation in simultaneous operation on different parts of an island.

Such varying calls for power have made the path of the electric power salesman much easier than he would otherwise find it, for although as yet operation by electric power is not quite as cheap as gas and steam power, still the elasticity and continuity of service afforded wins the load. The possibilities of combined reclamation and irrigation throughout various districts of the West, thus offer an ever broadening horizon for the consumption of electric power.

---

**The Value of Natural Gas**

The early entry of natural gas into the metropolitan district of Southern California as a competitor of manufactured oil gas and electrical energy, makes the subject one of timely interest. The tremendous growth of the crude petroleum output in California has been the marvel of all

As is often the case, however, certain by-products of an industry, at first unrecognized and unheralded, soon begin to rival the importance of the principal. Within the next few weeks natural gas is to be transmitted from Bakersfield into Los Angeles—a truly long distance transmission of heat energy. To those familiar with the awful waste of former days in Eastern natural gas fields, the lesson is an impressive one. When we consider the profligate manner in which millions of dollars in natural resources were lost forever to the uses of human endeavor, it would seem that Western industry is to be congratulated upon a farsighted policy of utilizing this enormous natural by-product of the oil-fields. True conservation should lead every high-spirited citizen to lend all reasonable support to any undertaking which puts to a useful purpose unharnessed energies that otherwise go by the board never again to be replaced. In the case of the utilization of natural gas, however, something more than mere sentimental satisfaction is in sight. It is not generally known, but the fact is nevertheless true, that the value of natural gas produced in this country in 1911, for instance, foots up the enormous total of $74,127,534, as compared with $134,044,752 for crude petroleum.

# PERSONALS

ITEMS FOR THIS DEPARTMENT ARE SOLICITED FROM ALL READERS

**Chas. W. Hobson**, founder of the Jovian Order, is in San Francisco.

**N. R. Stansel** has returned to Douglass, Ariz., after a visit to San Francisco.

**H. E. Grant**, sales engineer with the Holophane Com pany, is at Los Angeles.

**A. B. Saurman**, of the Standard Underground Cable Co., is making a trip throughout the East.

**W. W. Briggs**, sales manager of Westinghouse Electric & Manufacturing Co., has left for a flying trip East.

**R. D. Holabird**, of the Holabird-Reynolds Electric Company, has returned to San Francisco from an extensive Eastern trip.

**H. N. Lauritzen**, Pacific Coast manager for the Holo phane Company, has returned to his San Francisco offices after an extensive trip throughout the East.

**J. A. Spears** has resigned as sales engineer with the San Francisco office of the Holophane Company to join the illuminating department of H. W. Johns-Manville Company at San Francisco.

**Richard S. Buck** has retired from the firm of Sanderson & Porter and has become chief engineer of the Dominion Bridge Company of Canada. **Seton Porter** has been admitted as a member of the firm.

**A. B. Domonoske** has resigned his position as instructor in mechanical engineering at the University of California to accept a position in the mechanical engineering department at the University of Illinois.

**Kirk Bryan** of the U. S. Geological Survey has finished six months' investigation of the ground waters of the Sacramento Valley and left this week for Washington, D. C., where he will prepare a report of his investigations.

**R. C. Dwyer**, district manager of the Idaho Railway, Light & Power Co., at Caldwell, Idaho, has been transferred to the engineering department of the company at Boise. He is succeeded by **B. H. Wayne**, formerly connected with the Nampa office of the company. **L. D. Orr**, local manager of the Nampa office, will have general supervision of both the Caldwell and Nampa systems.

**Marshall C. McKay** has been appointed assistant electrical engineer of the Panama-Pacific International Expositon Company. Mr. McKay has had a wide experience in the construction and operation of Pacific Coast power plants and is peculiarly well qualified for his new duties. In accepting the position he has resigned as engineer in charge of construction and of operation in the generating and transmission system of the Sierra & San Francisco Power Company. The quarters of the electrical engineering department of the Exposition were moved to the Service Building on the grounds during the past week.

**Lee Hargood**, of the Lighting Department, General Electric Company, Schenectady, N. Y., delivered a lecture before the engineering students of Leland Stanford Jr. University on January 29th. The subject of Mr. Hargood's talk was "Automatic Voltage Control at the the Receiving Points of Transmission Lines by Means of Synchronous Machinery." The application of the synchronous condenser controlled with a Tirrel Regulator was discussed in detail. An interesting feature was brought out in that it was shown that by automatically controlling the wattless current in transmission lines, constant voltage difference can be maintained between the generating and receiving ends. By using suitable synchronous condensers properly located, this voltage difference can be maintained at practically zero. Such a method of operation means that power is transmitted at minimum losses, that substantially the maximum kilowatts can be delivered over a given line and the troublesome question of taps on the transformers for the high tension line is avoided.

## MEETING NOTICES.

### Oregon Society of Engineers.

The annual dinner of the Oregon Society of Engineers will be held in the Green Room of the Commercial Club, Portland, Thursday, February 13, 1913, at 6 p. m. It will be followed by annual business meeting, with speeches by prominent men.

### Portland Jovian Electrical League.

The Jovian Electrical League held one of the most successful luncheons ever held in Portland, on Thursday, January 30th, at noon, in the Hazelwood banquet room. Mr. B. Goodwin, chairman for the month, made arrangements for a very instructive and interesting lantern slide lecture, on the hydroelectric development on the White Salmon River, which is being done by the Stone & Webster Engineering Corporation for the Northwestern Electric Company. The lecture was given by Mr. J. H. Manning, superintendent for the Stone & Webster Engineering Corporation. The attendance exceeded 150 members and guests. Mr. C. P. Osborne was chosen by a unanimous vote for the chairman for the month of February.

### Oregon Technical Club.

Due to the fact that Mr. A. S. Moody was called to Seattle on business, he was unable to preside as chairman of the luncheon, but sent a substitute in the person of Mr. E. F. Whitney, of the General Electric Company, who conducted the meeting in a very creditable manner. Mr. W. B. Foshay, manager of the Northwestern Electric Company, spoke on his conmpany's present and future plans in and about the city of Portland. He stated that his company was rushing construction as fast as possible. That at present their plant on the White Salmon River is 85 per cent completed and that by March they expect to deliver 2500 h.p. to the paper mill at Camas, which is to be changed to electric drive throughout. The plant on the White Salmon River will be installed complete in nine months from commencing the installation mark. They have worked night and day without interruption. They have installed one of the largest wood stave pipes that is in existence. The diameter is 13 ft. 6 in. The same being especailly designed for this service. All material and apparatus orders have been placed for substation in Portland and for the distributing system within the city.

### Portland Jovians.

About fifty members of the Jovian Electric League met at the Hazelwood for luncheon Thursday, January 23d, to discuss different subjects of interest to the people in the electrical business.

A circular letter was distributed by Mr. R. G. Littler, president of the Oregon Electrical Contractors' Association, in reference to the matter of appointment by the state of a board of electrical examiners to examine into the qualifications of parties desiring to engage in the electrical contracting business. A synopsis of the letter was read by Mr. Weber of the Underwriters' Equitable Rating Bureau. A committee composed of Mr. Hartley of the Pacific States Electric Company, Mr. Moody of the General Electric Company, and Mr. Sailor of the Westinghouse Electric & Manufacturing Company were appointed to look into the matter and endorse the State License Law, which is to be introduced in the state legislature this session to regulate all electrical contractors in the state. After luncheon Mr. R. T. Guppy, chief engineer of the Portland, Eugene & Eastern Railway Company, spoke on the plans of his company to construct about three hun-

dred and fifty miles of electrically operated interurban lines, that would begin business in the Willamette valley. He also gave a description of the equipment to be installed, stating that it would be similar to the interurban lines now operating around San Francisco bay. The cars in use will be of steel construction, about fifty-six feet long. The approximate expenditure of this company will be twelve million dollars.

### Los Angeles Section A. I. E. E.

The Los Angeles Section of the American Institute of Electrical Engineers holds its regular monthly meeting at Hotel Hollenbeck, on Tuesday evening, January 28, 1913. President George A. Damon was in the chair. There were present 74 members and visitors.

Mr. Damon introduced Mr. Ralph D. Mershon, president of the Institute, who was the honored guest at this meeting. Mr. Mershon gave a very interesting address, reviewing the recently adopted new grade of membership in the Institute, also the possibility of a Pacific Coast Convention of the Institute for Los Angeles in 1914, and the patent situation in the United States.

The paper of the evening was "The Planning of Industrial Cities, with Special Reference to Public Utilities," by Ralph Bennett. It covered the general lay-out of streets and railroad rights of way, the location of railroad tracks for both freight and passenger service, the location of the business and residence section with reference to the industrial plants, the location of utilities, other than railroads, throughout the property, and use of alleys for such purpose and the limitations thrown on the best technical lay-outs by the necessity of land utilization. The paper was illustrated by steropticon views, showing the construction work in progress of the new industrial city of Torrence.

The following took part in the discussion: Messrs. Ralph Bennett, J. E. Macdonald, H. H. Sinclair, R. E. Cunningham, G. A. Damon, Budd Frankenfield and I. F. Dix.

E. R. NORTHMORE,
Secretary L. A. Section.

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## A NEW RECORD IN JOVIANISM.

The San Francisco Jovians set a new record, not only for the Pacific Coast, but also for this years administration throughout the country. when 119 candidates were rejuvenated at a great joviation and rejuvenation held at the Hotel Oakland, Oakland, Cal., on Feb. 5. ,

During the past week the Jovians have been the livest set of live wires in San Francisco. Frank E. Watts, Eleventh Reigning Jupiter of the Jovian Order, arrived on Monday evening, being met by an enthusiastic reception committee, who escorted him to his hotel and accorded him a royal welcome.

Jupiter Watts was the guest of honor at the regular weekly luncheon on Tuesday which was attended by nearly a hundred Jovians. Here he made a brief address on the recent great strides in membership and spoke of the enthusiasm in each of the cities which he has visited during his tour of inspection. An able address on the progress being made for the Panama-Pacific International Exposition was then delivered by Chas. H. Vogelsang, Commissioner on State and Foreign Organizations.

On Tuesday afternoon he was shown the exposition grounds and the city, and entertained in the evening in true San Francisco style. Likewise on Wednesday.

The crowning feature of his visit was the monster rejuvenation on Wednesday night when the San Francisco degree team conferred the full privileges of Jovianism on 119 candidates from the bay cities at the Hotel Oakland in the city of Oakland.

The rejuvenation was preceded by a banquet, where 220 members of the order gathered around the board. At the conclusion of the banquet Jupiter Watts gave a brilliant talk on the serious tasks which this great electrical organization has undertaken. Besides the practical commercial co-operation which is inculcated, special emphasis is being brought to bear on the question of remedying existing patent laws. The local organization was urged to do its utmost in urging congress to frame proper laws. Songs and music were interspersed with moving pictures of electrical subjects and a most enjoyable entertainment provided.

The rejuvenation was held under the direction of Arthur H. Halloran, statesman for California, with the active assistance of Alternate Statesman W. W. Hanscom, Statesman-at-Large T. E. Bibbins, and Past-Statesman J. E. Sanderson. Particular credit for the success of the rejuvenation is due to the membership committee, on account of whose energy and unselfish devotion this unusually large class was assembled. Those most active were: W. R. Dunbar (chairman); M. L. Scobey, A. E. Rowe, J. A. Hew, M. F. Steel and F. D. Fagan. The committee in charge of the banquet which preceded the rejuvenation was: W. W. Briggs, C. E. Wiggin; F. H. Woodward and J. E. Rowe.

The following officiated in the degree team: Jupiter, A. E. Drendell; Neptune, C. C. Hillis; Pluto, M. L. Scobey; Vulcan, A. V. Thompson; Mars, Albert H. Elliott; Averenim, F. H. Poss; Hercules, John R. Cole; Apollo, G. I. Kinney; Mercury, W. W. Hanscom; Imps, F. H. Woodward, H. E. Sanderson, J. A. Herr, M. F. Steel, W. R. Dunbar, H. A. Daley.

The following candidates were rejuvenated:

| | | |
|---|---|---|
| Abben, Oscar | Fibush, Martin E. | McKinley, W. L. |
| Abramson, Mono | Folte, Arno G. | Marcuse, S. |
| Alexander, Earl G. | Fyfe, Henry B. | Martinez, R. E. |
| Babcock, G. R. | Gensler, Julius | McCarty, Jas. H. |
| Baker, Fred D. | Gibson, Burton Y. | McKee, Jas. J. |
| Baker, Walter R. | Greenhouse, —, | Meinema, Albert |
| Bantel, Chris F. | Gilkyson, Jno. W. | Mellman, Henry |
| Batchelder, Harry S. | Gilman, Samuel W. | Myers, Romaine W. |
| Baumbaugh, Ernest C. | Gregg. W. H. | McManus, J. A. |
| Beck, Frank G. | Gribble, Wm. H. | Nylen, A. H. |
| Behan, R. F. | Hampton, E. J. | Neelands, Wm. L. |
| Belden, J. H. | Harkness, Harold L. | Paine, Henry E. |
| Bigelow. Chas. L. | Hasselbach, Henry C. | Plankington, J. C. |
| Bowes, Geo. T. | Hatch, W. G. | Quinn, Edw. A. |
| Brackett, J. H. | Havey, Harry D. | Quinn, Frank J. |
| Burns, Wm. T. | Hawken, Samuel L. | Quick, C. E. |
| Byers, Lande S. | Heise, Carl E. | Rawdon, Walter F. |
| Crowson, E. A. | Howard, H A. | Reid, Henry C. |
| Carlson, J. M. | Helfrich, L. C. | Rhine, M. |
| Carrigan, Andrew | Hermans, Jas. P. | Richmond, Jos. A. |
| Chamblin, Clyde L. | Hancock, S. L. | Rosenlund, Edw. T. |
| Cheney, Arthur H. | Hill, Benj. C. | Saurman, Atlee B. |
| Collins, Thos. E. | Hudson, Robt. A. | Schloss, Lyman A. |
| Cone, Wm. S. | Hyde, Henry C. | Schnapp, M. H. |
| Cooley, Frank N. | Johnson, Willard C. | Shreve, Earl O. |
| Coffin, E. M. | Jones, Geo. D. | Sibley, Robt. |
| Cox, Harry P. | Kahn, Raymond T. | Smarr, Ben M. |
| Cunningham, E. T. | Kimball, Hugh W. | Somers, Louis A. |
| Cutting, Edwin M. | Kinney, Herman B. | Sperry, Lewis E. |
| Dahlen, Arthur J. | Koch, Geo. A. | Shields, Howard E. |
| Dewald, Edward G. | Laingor, John S. | Thompson, Jos. S. |
| Dickinson, R. N. | Lazarus, Jos. G. | Tudhope, Geo. V. |
| Dillingham, Jos. O. | Leggett, Fred H. | Van Haren, Elvin E. |
| Dredge, Theo. F. | Lewis, Wm. B. | Van Hoosear, Jno. E. |
| Doyle, Harrison M. | Lillard, O. W. | Wentworth, Geo. L. |
| Dyer, E. K. | Loughborough, A. R. | Werner, Wm. M. |
| Drew, G. G. | Lutz, Aug. J. | White, Howard J. |
| England, J. A. | Loring, C. A. | Wilson, John E. |
| Emery C. G. | Morris, T. C. | Wolfe, Harold S. |
| Ellis, Norman P. | MacPherson, H. F. | |

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## NEWS OF CALIFORNIA RAILROAD COMMISSSION.

Jan. 29.

Upon complaint of the Board of Trustees of Sutter Fort against the San Francisco-Oakland Terminal Power Company, a decision was rendered ordering the restoration of the $60 rate. The company had advanced the season rate to $95.60 at Coloma, El Dorado county, without proper authorization.

A decision was rendered on the application of various public utilities for permission to charge less than the published schedule of rates in certain classes of rates. The decision permits deviations for federal and state governments and the political subdivisions thereof, including the departments thereof, and public institutions, fairs and other public expositions and celebrations, charity as defined in the opinion in this case, and employes.

# THE ELECTRICAL CONTRACTORS' DEPARTMENT

## EXAMINATION FOR CHIEF INSPECTOR OF ELECTRICITY, PORTLAND, OREGON.

### Theory and Practice of Electricity.

1—What governs the various sizes of wires in an installation of wiring?

2—Which is the most important in wiring problems?

3—What is the characteristic feature of the constant potential system?

4—Find the power in watts in a closed circuit in which an electrical energy equivalent to 123,750 foot-pounds is expended in 43.5 minutes.

5—What takes places in a conductor when it is moved across lines of magnetic force at right angles to their direction?

6—(a) In a circuit, the resistance between two points is .23 ohm; what current flowing between these points will cause a difference of potential of 48.4 volts? What is (b) the power in watts? (c) its equivalent in horsepower units?

7—Why is high voltage used for distributing power to great distances?

8—The total resistance of a closed circuit is 12.3 ohms; what is the power in horsepower units when a current of 11.4 amperes is flowing through the circuit?

9—What is the distinction (a) between a ring-wound and a drum-wound armature? (b) between a cylinder and a disk armature?

10—Why is the difference of potential between the terminals of a dynamo armature less than the e.m.f. generated, when the machine is delivering a current?

### Electrical Wiring and Apparatus.

1—Why is the use of wire smaller than No. 4 prohibited by the Code except as allowed for fixture work?

2—(a) What is a constant current system? (b)What is a constant potential system?

3—How are three-way switches considered by the National Electric Code? How should they be wired to comply with the requirement of the Code rules?

4—When is the use of metal moulding prohibited by the rules of the National Electric Code?

5—How much above the allowable carrying capacity of the wire may circuit breakers be set; (a) when a fusible cutout is also installed in the circuit; (b) when no fusible cutout is installed?

6—What pressure is usually employed for 32 c.p. incandescent lamps?

7—How should electric heaters be installed to meet the requirements of the National Electric Code rules as to protection and control?

8—Why does the Code require that cutouts be so placed that no set of incandescent lamps requiring more than 660 watts shall be dependent upon one cutout.

9—What determines the places of contact of the brushes upon the commutator of a generator or motor?

10—Is there ever any danger of wires becoming dangerously overloaded if such wires were originally installed in strict accordance with the rules of the Code? State your reasons.

### Practical Questions.

1—What advantages does direct current possess over alternating for commercial purposes?

2—What advantages does alternating current possess over direct current?

3—How many amperes equal one horsepower on a 110 volt circuit?

4—What size of wire must be installed to comply with the requirements of the National Electric Code to connect a d.c. motor rated at 80 amperes 110 volts to a circuit the length of which is 40 feet and the drop in which is 40 volts?

5—A circuit requiring 320 amperes is to be installed, the distance from the meter is 280 feet, the voltage is 220; it is desired to keep the drop within 2 per cent, state what size of wire should be installed to comply with the Underwriters' rules.

6—(a) What is the principal advantage of the three-wire system? Explain fully. (b) When may the neutral fuse in a three-wire system be omitted?

7—What are the requirements of the National Electrical Code for the installation of series arc lamps, also multiple arc lamps?

8—If the alternating current mains of a large building are so large that they will not go into one conduit, how should they be installed?

9—Does a blown fuse always mean that there is a short circuit or an overload? State fully.

10—(a) What part of a generator forms in reality a part of the light circuit? (b) What per cent of the whole resistance of a circuit should the lamps connected thereon be?

## TRADE NOTES.

The name of the Simplex Electrical Company of Boston has been changed to Simplex Wire and Cable Company. No change of management or interest is effected by the change of name.

The Ohio Brass Company of Mansfield, Ohio, recently secured the exclusive sales rights for the National Railroad Trolley Guard, which is a patented device for preventing electric cars from becoming stalled on steam road crossings when the trolley wheel leaves the wire.

The Oro Electric Corporation have contracted with C C. Moore & Co. to build a steam plant near Stockton, Cal., as an auxiliary to its extensive hydroelectric system. The first installation will be a 1000 kw. unit, but the plant has been arranged to be extended by adding several larger units, as the business of the company demands. The plant will be constructed in accordance with the best practice in steam engineering. The turbine will be of General Electric make and the boilers B. & W. Stirling type. This plant will be so located that ample condensing water will be available. It will also have both rail and water transportation facilities The contractors have been given orders to rush this plant which is to be ready for operation on May 1st of this year

## NEW CATALOGUES.

Sprague Electric Works' publication No. 117 is a handsomely printed listing of the various products they manufacture. For more detailed description reference is made to special bulletins.

Bulletin No. 102, "Proper Lamp Voltages," from National Electric Lamp Association, is a discussion of the selection of incandescent lamps for use on circuits having a fluctuating voltage. Commercial relations of lamp voltage and line voltage are not considered.

"How to Figure Illumination" is the title of a twenty-page booklet recently published by the Sunbeam Incandescent Lamp Works of the General Electric Company. The object of this bulletin is to acquaint the general public with the most simple and up-to-date method of figuring commercial and industrial illumination. It also includes a complete catalogue of Sunbeam Mazda lamps.

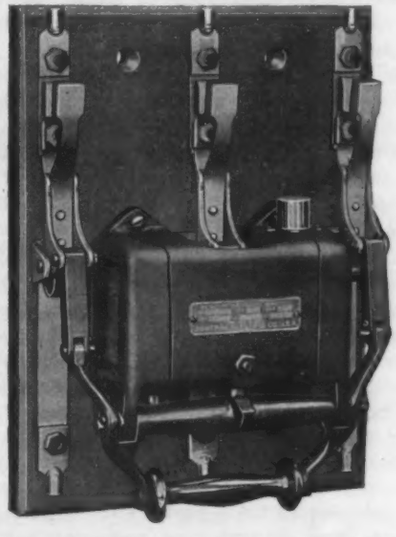
# INDUSTRIAL

## DIESEL ENGINES IN BRITISH COLUMBIA.

The Municipality of Penticton, B. C., is installing a 200 h.p. Diesel engine made by Mirlees, Bickerton & Day of Hazel Grove, near Stockport, England, as a prime mover for the municipal lighting system. This will suffice until the present population of 2500 increases sufficiently to warrant the construction of a more extensive hydroelectric development. A similar engine has been recently installed at Vernon, B. C., and seven other plants ranging from 150 h.p. to 900 h.p. in Saskatchewan. A working test of the 200 h.p. engine at the factory showed a mechanical efficiency of 77 per cent at full load, the fuel consumption being 0.425 lb. for b.h.p., the oil having a calorific value of 18,000 B.t.u. per lb. F. H. Latimer has charge of the installation at Penticton, as well as of the municipality's irrigation and domestic water system.

## THE DISTANT CONTROL OF SMALL CAPACITY POWER AND LIGHTING CIRCUITS.

In addition to the service of transmitting messages to distant points instantly, electricity is also utilized to do things at some distant point, and thus also effect a great saving in time, expense and labor. A lighting company furnishing power on a flat rate basis for the operation of signs received numerous complaints when the electrical current was turned off by hand owing to the attendant's inability to be at all the places at one and the same time so as to switch the current off all signs simultaneously. The complaints disappeared when the current was cut off by remote central switches all tripped simultaneously by the throw of a switch at the station.



Electrically Operated, Triple Pole, Remote Control Switch.

Such a distant control switch has a wide field of application. The one shown in the illustration is substantially built and has few operating parts and so is suitable for installation at remote points where it may not receive a very great amount of attention.

The switch is operated by a double coil solenoid—one coil for closing and one for opening—controlled by a special double push button switch which is normally in the open position and remains closed only while held so by the operator. To open or close the switch the corresponding push button has to be pushed in. One of these switches is furnished with each remote control switch and must always be used, as the solenoid coils are not designed to conduct their exciting current continuously. The cores of the operating solenoids are connected directly to the operating lever which in turn is connected to the poles of the switch through a toggle mechanism. When a coil of the solenoid is energized, its core moves the operating lever up or down, forcing the switch closed or opening it, whichever action corresponds to the coil energized. The switch can be operated by hand also, a handle being provided for this purpose and seen at the lower part of the switch in the cut.

Specially Designed Push Button Switch.

This switch is a self-contained unit with two sets of contacts, the main contacts being laminated copper brushes, while the auxiliary ones, on which the arc breaks on opening the circuit, are of carbon. The main contact brushes are so constructed that each lamination makes an end-on contact stud without any tendency to force the laminations apart. The laminations have a wiping effect in closing, thus keeping the contact surfaces bright, and ensuring good contact always. The carbon auxiliary contacts are made of blocks of selected carbon fastened on without screws or bolts, which ensures long life and satisfactory service.

The standard finish of all the live parts of the switch is polished copper, while that of the mechanism is marine (dead black).

The switch is made single, double, or triple pole, single throw for service on alternating and direct current circuits for potentials of 110, 125, 220 and 250 volts, and can be furnished up to 300 amperes capacity.

Besides the service mentioned above it can be used to open or close power or lighting circuits of comparatively small capacity at some distant point. It is also used in office buildings, libraries, and public buildings, being installed in the supply circuits of cabinet panels and controlled from any desired point.

The switch described above is manufactured by the General Electric Company, of Schenectady, N. Y.

## ELECTRIFICATION OF THE MELBOURNE SUBURBAN SYSTEM OF THE VICTORIAN RAILWAYS.

Probably the most notable railway electrification project at the present time is that about to be undertaken in connection with the suburban steam railways of Melbourne, Australia. The advisability of the step has been under consideration for a number of years, and in 1908, Mr. Charles H. Merz, of the firm of Messrs. Merz & McLellan, Victoria

street, Westminster, London, presented a comprehensive report on the subject to the Victorian Railway Commission. In this report, Mr. Metz, acting as consulting engineer on the scheme, went very fully into the whole question of the substitution of electric traction on steam railways.

In a later report, embodying a comparative analysis of the merits of both the single phase alternating current and high voltage direct current systems, based on the tenders submitted, Mr. Merz points out that the adoption of the high tension direct current system for this application would mean a saving of about $3,500,000, or nearly 30 per cent. in the cost of installation over that of the single phase system. Accordingly, in view of this initial saving and a further operating economy, as indicated by Mr. Merz, of about $350,000 per annum, or nearly 28 per cent., he recommended very strongly the adoption of the high tension direct current system for the Melbourne Railways and the Victorian Government accepted his recommendations.

The electrification of the Melbourne Suburban Railways is of exceptional interest because it will be one of the largest projects of its kind in the world, involving heavy rolling stock equipment with overhead collectors. The magnitude of the undertaking from the standpoint of equipment and service may be compared with that on the third rail electrified section of the New York Central Railroad out of New York City, and ranks with the Oakland, Alameda & Berkeley electrification of the Southern Pacific Railroad at San Francisco.

Naturally, the great size and tremendous importance of the project attracted world-wide competition, and among the leading manufacturers of electrical apparatus submitting tenders are included the Allgemeine Electricitaets Gesellschaft, Berlin; British Westinghouse Company, Manchester; Dick, Kerr & Company, Ltd., London; Ferranti, Ltd., Hollinwood; Siemens Bros. Dynamo Works, Ltd., London; General Electric Company of New York, and others. After an exhaustive study and consideration of the relative merits of the several propositions, Mr. Merz approved in his report the recommendations of the General Electric Company of New York as to choice of system and economical features of operation, and the Victorian Government awarded this company the contract for the rolling stock apparatus equipment, comprising 400 motor car equipments, consisting of four motors each; 800 control equipments, 400 of which are for trailer cars, and 400 air compressor equipments. This is the largest single order ever placed for electric railway apparatus.

The mileage of the suburban lines included in the scheme is made up of 150 route-miles, or 289 track-miles of running roads, and 34 miles of sidings. The potential selected for this direct current system is 1500 volts. Power will be supplied from a central station at Yarraville, a suburb of Melbourne, in the form of three-phase alternating current at 25 cycles per second and will be transmitted at 20,000 volts to twelve substations at various points on the system, where it will be converted into the operating direct current of 1500 volts. The high tension transmission is by underground cables from the power house to the important substations in the central area, and by overhead wires erected on the same structures which carry the railway track conductors, to the outlying substations. Overhead conductors will be used throughout the system for supplying current to the trains, which will be equipped with roller pantograph collectors. The complete equipment of the railways involves the expenditure of $12,000,000 in round numbers, and Mr. Merz figures the saving of electric operation will amount to about $600,000 in 1915 over the former steam operated lines.

Normal trains, weighing about 180 tons, will consist of two motor coaches and two trailer coaches. The tracks are 5 ft. 3 in. gauge. The suburban traffic amounted to 70,000,000 passengers in 1908; the figure the past year exceeds 90,000,000; and in 1917, when it is expected that the conversion to electric operation will be entirely completed, it is estimated that the suburban lines will carry 150,000,000 passengers per annum. The present plans are accordingly based on provision for this probable increase in the passenger traffic; but all parts of the electrification scheme are arranged so as to be capable of extension from time to time, as the traffic subsequently grows. Handling heavy traffic during the rush hours of morning and evening will be provided for by increasing the length of trains, although for this initial service it is the intention to have the maximum train consist of six coaches.

The motors, numbering 1600 in all, which will be installed in the 400 motor coaches, will be of new design throughout and will embody the most modern developments that the General Electric Company has introduced in railway motor construction. They will be known as Type GE-237, will have inherent ventilation and be provided with commutating poles. They will be rated 140 horsepower at 725 volts and will be operated two in series on 1500 volts.

The method of self-ventilation which will be incorporated in the design of these motors will assure exceptionally effective and uniform cooling. This will be accomplished by a broad-bladed centrifugal fan cast intergral with the pinion end armature core head. Fresh air is drawn into the interior through a screened opening on the upper side of the motor frame at the pinion end. This is circulated over the armature and field coils, under and through the commutator, through longitudinal holes in the armature core, and thence exhausted to the exterior through openings in the pinion and bearing head.

The service on the lines calls for both local and express schedules. The motors will therefore be arranged for tap field control, which will allow a free running speed of 52 miles per hour over level track for the suburban cars on express runs. This method of auxiliary control was introduced by the General Electric Company a number of years ago, but due to commutating limitations of earlier motors, it was eventually abandoned. Its successful application to commutating pole motors is therefore modern.

The 800 control equipments for both motor and trailer cars will be the well-known Sprague-General Electric Type M relay-automatic control and do not require description. They provide for multiple unit operation and control of the train from the platforms of any motor or trailer car. Type M control has been in operation on heavy traction work for many years, notably on the subway and elevated divisions in New York and other large cities, and has demonstrated its simplicity, low maintenance and reliability.

It is interesting to note that two of the principal factors that apparently influenced Mr. Merz and the commissioners to decide in favor of the high tension direct current system, rather than the single-phase alternating current system, were the lower maintenance of the rolling stock equipment and the saving in energy consumption. They found that the greater number and complexity of the electrical parts carried on the coaches in the case of the single-phase equipments not only causes these equipments to be initially more expensive, but also renders them more costly to maintain; and when routine inspection is taken into account, and also the fact that repairs are necessarily subject to the exigencies of traffic requirements, the maintenance of single-phase equipments would exceed that of direct current equipments in a slightly higher proportion than that governing their respective first costs.

Electrification of steam roads both here and abroad has emphasized the fact that the conversion to electrical operation is always accompanied by a faster and more frequent train service, and because of greater convenience, comfort and cleanliness, a general improvement in suburban traveling conditions, while the reduction in working cost and the increased earnings of the line combine to produce larger profits.

# NEWS NOTES

### INCORPORATIONS.

BAKERSFIELD, CAL.—Southern California Gas Company, $10,000, by A. N. Kemp, A. C. Johnson, E. R. Davis, H. P. Baumgartner and Chas. Foreman, all of Los Angeles.

### ILLUMINATION.

EL PASO, TEXAS.—Notice has been given that the El Paso Gas & Electric Company will apply to the city council for a franchise to maintain and operate a gas plant in this city.

VISALIA, CAL.—The Central California Gas Company has secured permission to lay gas pipes in the county roads that the Porterville, Lindsay, Exeter, Visalia and Tulare stations might be connected.

INGLEWOOD, CAL.—The Los Angeles county supervisors have awarded the contract for street lighting of Hyde Park to the Southern California Edison Company. The system is to be installed by June 1.

PORTLAND, ORE.—Ornamental street lighting for Sandy Road is the scheme of the Rose City Park Club. The proposition is to illuminate the boulevard with electroliers from Burnside to East Seventy-second street.

SALT LAKE CITY, UTAH.—Extensive improvements in the gas systems of this city to meet the needs of the city's growing business and residential sections are to be carried out this year by the Utah Gas & Coke Company.

BREMERTON, WASH.—An application for a gas franchise was presented by E. R. Downie of Seattle. The franchise is asked in the name of Chas. R. Shepherd, a principal stockholder in the gas plants of Everett, Raymond, South Bend and Montesano.

ANAHEIM, CAL.—Sealed bids will be received up to February 5th for a franchise to lay and maintain a pipe line along certain portions of Orange county for the purpose of transmitting natural gas for light, heat and power purposes, in accordance with conditions set forth in terms of the franchise.

SAN FRANCISCO, CAL.—An opinion against the Pacific Gas & Electric Company's claim of franchise rights has been given to the Board of Supervisors by City Attorney Long, who says that this company stands on the same footing as other lighting companies and that the only rights belonging to it with regard to the use of streets are such as it acquired under section 19 of article 11 of the state constitution. This section was amended in October, 1911, and the laying of pipes and conduits and erection of poles on streets cannot now be carried on in the free way allowed prior to the amendment, as the regulating power of the municipal authorities has been increased. The Pacific Gas & Electric Company based its franchise claim on order No. 1667, which was passed by the supervisors on March 20, 1882, and it relied also on resolutions adopted by the board in 1881 and 1899. The city attorney holds that the supervisors had no authority either under the old consolidation act or any other enactment to grant this franchise.

### TRANSMISSION.

TOLEDO, ORE.—Lewis Montgomery of Portland has purchased the Toledo electric plant. He plans new machinery in a building which will erected especially for a power plant.

YUCAIPA, CAL.—Surveys are now being made for extension of the high power lines of the Southern California Edison Company from Mentone into and through Yacaipa valley.

MODESTO, CAL.—Chas. Northcutt, representing the Sierra & San Francisco Power Company has been granted permission to run a power line along the county road from the Oakdale road to Claus.

SIERRA CITY, CAL.—Dennis Phelan, managing director of the Sierra Mercantile Power & Mining Company, is in San Francisco arranging for the purchase of machinery for an electric power plant to be erected here in the spring for the operation of the Sacred Mound mine and mill.

RENO, NEV.—Following the filing of a trust deed for $3,000,000 to obtain bonds to the amount, engineers of the Mono Valley Power & Light Company have been instructed to commence work on a power plant below Reno. A large dam is to be constructed just above the government's dam at Derby. Work must be started within six months, according to the trust deed which was filed in Washoe and Storey counties. The company is to supply power to Reno in competition with the present Truckee River General Electric Company's plant. The Mono company already is supplying Goldfield and Southern Nevada camps with power. The company is backed with Oakland capital.

TULARE, CAL.—The hearing of the application of the Tulare County Power Company before Commissioner Loveland for leave to issue $300,000 6 per cent gold bonds called forth unexpected opposition. Just as A. M. Drew of Fresno and W. H. Orrick of this city, counsel for the company, were about to open their case, Jesse W. Lilienthal appeared with an intervention on behalf of the Mt. Whitney Power & Electric Company, and Robert J. McGahie filed an opposition to the granting of the application on behalf of Fred W. Corcoran, a dissatisfied holder of the preferred stock. The opposition of the Mt. Whitney company is based on the threatened invasion of its territory by the Tulare concern. C. H. Holley, the secretary and general manager of the Tulare Company, testified that the proceeds of the bond issue were to be utilized in paying off an indebtedness of $228,000 and for constructing an additional distributing system and developing a water right on Tule River. His company, he said, was operating 234 miles of electric distributing lines in Tulare county now, and desired to add 100 miles more to accommodate customers who had contracted for current.

SAN FRANCISCO, CAL.—City Engineer M. M. O'Shaughnessy and A. W. Maltby, a water power expert of New York City, sat as representatives of Secretary of the Interior Fisher in an all-day conference in the postoffice building, hearing all sides in the Lake Tahoe dispute. Representatives of the Lake Tahoe Protective Association argued against any scheme for constructing a dam and enlarging the natural channel of the Truckee River so that more water would be drawn from the lake than ordinarily flows out in the course of a year. The U. S. Reclamation Service, represented by Engineers Hobson and Davis and by John F. Truesdale, special assistant to the attorney general, sided with the representatives of the Truckee River General Electric Company in the plea for the privilege of lowering the body of water six feet if necessary. The lowering of the level of Lake Tahoe, according to W. M. Bliss, who represented the owners of the Tahoe Railway, the Tahoe Tavern and the other big resorts along the shore would result in damage amounting to $1,500,000 rendering certain localities along the southern side of the lake inaccessible by steamers because of shallows.

## TRANSPORTATION.

LOS ANGELES, CAL.—The city council has sold the 21-year franchise for the extension of the Vernon avenue car line to the western city limits, to H. E. Huntington.

MEDFORD, ORE.—The F. P. Minney Company of Oakland, holders of an electric road franchise in this city, which plans to construct interurban lines throughout the Rogue River Valley, has closed a deal for the purchase of the F. W. Waite tract, 1½ miles from Ashland. The tract consists of approximately 2000 acres. The price was $400,000.

LOS ANGELES, CAL.—Bonds in the sum of $5000 to provide satisfactory completion of the laying of tracks by the Pacific Electric Company on San Pedro street, to be used by the Pacific Electric and municipal railways, has been approved by the city council. According to the terms of the contract the Pacific Electric is allowed five months to complete the work.

SAN FRANCISCO, CAL.—A resolution has been adopted by the supervisors' public utilities committee calling upon the United Railroads to extend the Brannan street line on to the Mail docks. This will require only a block of single track in First street and an outlay of but $5000. The United Railroads wants a permit to make a switch connection at Presidio avenue and California street to run empty cars of the Jackson street line to the Clement street carbarn. The company will get the permit if it guarantees to build the much needed line to the Mail docks.

FRESNO, CAL.—The Fresno-Hanford Summit Lake Railway Company has applied to the Railroad Commission for authority to issue $1,250,000 of bonds. It is proposed to use the proceeds in the construction of an electric railroad running from Fresno easterly to the town of Centerville, Fresno county, and southeasterly to the town of Kingsburg, Fresno county. The distance is 40 miles. The applicant states that it has procured practically all of the needed rights of way and has completed the roadbed over most of the route, and has constructed culverts over all waterways. It states also that it has obtained the necessary franchises.

SAN FRANCISCO, CAL.—Plans and specifications for the extension of the Geary street road to the Ferry have been approved by the supervisors' public utilities committee, and the board of works authorized to call for bids for the laying of the tracks from Kearny street down Market to Sansome, where the cars will proceed on outer tracks to the Ferry loop. City Engineer O'Shaughnessy announced that all is in readiness for building the extension, and that provided no legal obstacles are thrown in the way, the Geary cars will be running to the waterfront in 40 days. Regarding the westerly extension from thirty-third avenue to the beach, O'Shaughnessy said that the grading is now under way and will be completed in 30 days. Within 60 days the tracks will be laid and cars running to the ocean terminal.

OAKLAND, CAL.—The San Francisco, Oakland & San Jose Railway, the name under which the Key Route now operates, has taken the first step towards converting its present Key Route pier into a mole by awarding a contract to Twohy Bros. for the filling in of the Key Route pier at a cost approximating $2,000,000. Work is to be started immediately, and, while the contractors fill in the pier they will increase the number of tracks from two to eight. While the Key Route's plans for the enlargement of its terminal facilities at Oakland provide for an immediate expenditure of but $2,000,000, the improvement work will ultimately cost in the neighborhood of $7,000,000, the latter sum covering the cost of erecting new and more extensive train sheds and the installation of junction points along the pier for the accommodation of freight traffic. The Key Route pier, according to the terms of the contract, is to be filled in with granite, rock and gravel and made as substantially solid as possible. Most of the rock is to be taken from the big hill between Piedmont avenue and Broadway, just outside of St. Mary's Cemetery. In some places, especially where junction points along the pier are to be established, the new mole will be 1000 feet wide. Twohy Bros, the construction firm awarded the contract for the pier work, were formerly located in Spokane and did much of the extension work for what is now the Oregon-Washington Railroad & Navigation Company. When they begin the work for the Key Route it will be the first time in many years that they have been engaged on anything save Harriman railroads.

## TELEPHONE AND TELEGRAPH.

ALPINE, TEXAS.—The business men of this city are considering a project for financing a co-operative telephone exchange.

PRESCOTT, ARIZ.—The 4-mile telephone line running from Thompson valley to Hillside station on the San Francisco, Prescott & Phoenix Railroad, has been sold to J. D. Cage by L. O. Phippeney.

BLYTHE, CAL.—Announcement has been made that the Imperial Telephone Company has sold the valley plant to the Pacific Telephone & Telegraph Company and that the latter will soon start to rebuild the entire system.

REEDLEY, CAL.—E. W. Crosby and associates, owners of the Reedley Telephone Exchange, have sold their interests to A. Terkel of San Francisco, who, at the present time, is superintendent of the commercial department of the Pacific Telephone & Telegraph Company here. The capital stock of the new Reedley company, which will be known as the Reedley Telephone Company, is $25,000, and the majority of the stock has already been sold. The incorporators are: A. Terkel and Dr. Ira Dick of San Francisco, Dr. G. H. Therhof of Livermore, D. C. Krehbiel and E. W. Crosby of Reedley. The new owners state that they will make a number of improvements.

## WATERWORKS.

VALLEJO, CAL.—About 300 water meters will be purchased by the city. A provision of $3000 for this purpose was included in the budget for the present fiscal year.

LOS ANGELES, CAL.—Commissioner Loveland of the State Railroad Commission, heard the application of the San Dimas Water Company to purchase the entire holdings of the San Dimas Irrigation Company, the Artesian Belt Water Company and the Charter Oak Reservoir Company. No protest was entered against the proposed purchase.

RENO, NEV.—The councilmen have been convinced that the present system of the Reno Power, Light & Water Company is entirely inadequate to supply the city during periods of winter weather. The committee submitted a report stating that investigation had been made and the only remedy was the piping of the Highland ditch and the establishment of a subsidiary pumping plant. This matter will be taken up at the next meeting of the council.

GLENDALE, CAL.—The Verdugo Pipe & Reservoir Company has asked for bids on about 1100 feet of second-hand 3-inch No. 16 sheet steel water pipe stored on the grounds of J. P. Lukens, on the roadway near Verdugo road. Included in the same lot is a quantity of 4-inch (second-hand) which will go with the 6-inch pipe without charge, value taken into consideration on bid for first described pipe.

SAN FRANCISCO, CAL.—Supervisor Andrew J. Gallagher's plan for the extension of water mains to suffering districts by use of Hetch Hetchy funds has been approved by the supervisors' utilities committee. A resolution was adopted calling upon the board of works to purchase the pipe and prepare plans for the installation of the mains in the Richmond district in the blocks bounded by Geary street, Thirteenth avenue and Twentieth avenue.